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FORECASTING THE DEMAND FOR FREIGHT TRANSPORT IN CANADA:

A Time Series Approach

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FORECASTING THE DEMAND FOR FREIGHT TRANSPORT IN CANADA: A TIME SERIES APPROACH

Report on Phase Three of the Program

by

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PREFACE

This paper reports on work done by the Research Branch between November 1977 and April 1978, to forecast the demand for freight transport in Canada. The approach taken relies on time series analysis, and is intended to complement previous econometric work in the area. As the present study was envisaged as a methodological exploration to illustrate the strengths and limitations of time series analysis, it was decided to deal with only three groups of commodities: coal, newsprint, and chemicals and chemical products. These commodity groups were chosen in consultation with officials from Transport Canada.

From the start, work in the area of forecasting freight transport demand has been carried out in close cooperation with Transport Canada and the Research Branch is grateful for this mutually fruitful and productive relationship. This report concludes the final phase of the Freight Transport Forecasting project, and the examination of the various forecasting methodologies.

It is hoped that the contents of this report will be of general interest. The views expressed herein, however, are not necessarily those of the Canadian Transport Commission.

Yves Dubé
Vice-President Research

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EXECUTIVE SUMMARY

This paper reports on work carried out by the Research Branch of the Canadian Transport Commission, from November 1977 to April 1978, on forecasting the demand for freight transport. This work arose out of a meeting between officials of Transport Canada and the Research Branch, in early November, 1977.

The Research Branch has been active for some time in the construction of models for forecasting freight transport demand.[1] Previous efforts involved estimating regression models, by attempting to trace the causality between specific economic activities in various sectors of the economy, on the one hand, and the demand for freight transport on the other. These structural models were then used to provide conditional forecasts: future demand would depend on the state of various sectors of the economy.

In November 1977 it was decided to complement the earlier models by constructing forecasts based on time series methods. These methods are characterized by reliance on the continuation of established trends and are believed to be useful in those cases where enduring institutional relationships predominate. Time series forecasts are valid

[1]For a discussion of previous work see Report on Modelling the Demand Freight Transport, Research Branch, Canadian Transport Commission, 1976.

for the short to medium term, and ideally should not be for more than several years; however , like any other forecasting techniques, they can be used for longer time spans. For the sake of comparison with the previous regression models, we extended the time series forecasts to 1985, although the latter part of such forecasts is to be viewed with extreme caution.

The methodology of time series models is basically quite simple, although the actual mathematical formulae used are sometimes elaborate and technical. The underlying idea is that, for many natural and human phenomena, patterns of behaviour persist over time. This principle cannot be logically proved,[2] but in practice it is often an adequate base for constructing forecasts. It is particularly appropriate in certain areas of freight transport, where traditional markets or sources of supply, reinforced by ownership constraints, tend to discourage deviations from past patterns of transport flows. In the absence of significant new information, therefore, reliance on past patterns seems reasonable.

Essentially, time series analysis seeks to discover these past patterns and to project them into the future.

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[2] For a discussion of this point, see D. Hume, An Inquiry Concerning Human Understanding, (Indianapolis, Ind: Bobbs-Merrill, 1955). The original edition was published in 1748.

Intuitively, the procedure is as follows. The present month's value for the variable in question is compared to the value in the previous month, the value two months before and so on. This is to identify the speed of adjustment of the variable, and to discern any systematic growth in the short run. Comparisons are also made with the value in the same month the previous year, two years ago, and so on: in addition to taking into account seasonal patterns, these comparisons will also help identify more gradual, longer-term growth patterns. The trend and seasonal pattern identified is removed from the original time series, and the variability of the remaining residuals is examined. If little systematic variation is left, the pattern is believed to capture the essence of the time series, and thus to furnish a good forecast. If much variation remains, the pattern will not be of much use for future projections, and other methods must be relied on.

In certain cases, a more sophisticated technique, taking into account features of both regression and time series models, was tried. This dynamic regression, or transfer function approach, seeks causal relations between the variable of interest and another, independent, variable. However, it treats both variables as time series as well. Thus separate time series models are constructed for each time series and the resulting residuals are correlated,

making allowance for the appropriate time lags. This methodology incorporates the best features of time series and regression analysis; unfortunately, it is quite cumbersome and lengthy to use. Its use was attempted during the present study, but the results generally proved to be only slightly better than those obtained from ordinary time series analysis, and thus was used for only a limited number of equations. The procedure is described in more detail in sections 4.9 and 4.10.

After discussions with the Strategic Planning Branch of Transport Canada, it was decided to examine three commodity groups, to see how the time series approach would perform. Coal, Newsprint, and Chemicals and Chemical Products, were chosen. The purpose of this choice was to study as wide a range of commodity groups as possible, to see what problems would occur. Thus coal is a bulk, unprocessed commodity which moves in very large quantities between a relatively small number of shippers and receivers. By contrast, chemicals and chemical products have already undergone processing and movements involve very many shippers and distributors. Traffic volumes are relatively small; the largest chemical flow studied is smaller than the smallest coal flow studied. Newsprint was chosen as an intermediate case, which in addition has peculiar problems of its own.

Results are presented in the report for different links for each commodity group. First, a short description of the institutional features of the production and consumption of each group is given. Next, time series models are constructed for the major origin-destination pairs; the models are then used to project traffic to 1985; confidence intervals are also shown. These forecasts are mainly for illustrative purposes, and the reader is again warned that forecasts from this type of model decrease in validity after the first few years. The model is based on monthly data, and so the forecasts incorporate expected seasonal variation. For comparison with results from the regression models, the monthly data are added up, and yearly totals are given. Where possible, the results from the two approaches are shown on the same graph.

To situate the results of the time series models in the proper context, discussions were undertaken with individuals both within the Commission and in other government departments, who knew the institutional framework for the different commodity groups, and who could express an informed opinion as to the future evolution of their markets. These consultations permitted refinement of the models to eliminate aspects which seemed due to statistical coincidences, rather than recognized phenomena.

The results of this study indicate that both regression models and time series methods have their place in forecasting the demand for freight transport. Sometimes the forecasts from the regression models seemed more reasonable; sometimes the results of the time series models were more in line with the opinions of outside experts. These occurrences agreed generally with our *a priori* expectations. For coal, for example, the industry seems dominated by institutional constraints. Long-term contracts are frequent; steel mills and electricity-generating plans are immobile; and partial or total ownership of coal mines by steel manufacturers is common. In addition security and continuity of supply sometimes seem more important than costs or other short-run advantages. Thus, the transport of coal is dominated by a continuation of established trends: patterns change slowly, and not always in expected directions. *A priori*, we would expect time series methods to do well here, and this is what we find. In most cases, for coal, the time series forecasts seem more reasonable than the forecasts from the regression model.

For chemicals and chemical products, the opposite is true. The market for these products is much more competitive, with large numbers of suppliers and buyers: thus short-run effects are more important. Institutional rigidities, such

as intercorporate ownership and long-term contracts, are less. Thus *a priori* we would expect less inertia, as the demand for transport responds to general conditions elsewhere in the economy. Again, we are confirmed in our expectations: time series methods detect slight or no patterns that can be used to project the future, while in general regression methods do better.

Several other differences between the two approaches should be mentioned; (a) the use of outside information, (b) stability of forecasts, (c) ease of update of forecasts, and (d) the use of causality in forecasting. Each of these issues is now discussed in turn.

The first point is that regression models rely heavily on exogenous variables to explain past behaviour, and thus to forecast future values. While past values of these exogenous variables, or at least proxies for them, are usually available, the same is not necessarily true for future values. Such broad aggregates as Gross National Product, Value of Agricultural Production, or Value Added in Manufacturing may perhaps be obtained from such macro-economic models as CANDIDE; but their future values must remain in doubt, as no macroeconomic model can be completely accurate. For more specific variables, such as production or consumption of a commodity in a given region in the future the task becomes much more complicated. Time series models,

on the other hand, rely only on the past history of the time series, and thus do not involve these problems.

The second point is the stability of forecasts. Due to the fairly uniform growth in the Canadian economy, and indeed in the world economy, over the last twenty years, the historical values for many production, consumption, and transport variables have tended to move together, i.e., be multicollinear. In such a situation, it is often very difficult to ascertain the impact on one variable of a change in another variable; for example, the effects of changes in production of a good on the demand for transport cannot be disentangled from changes in consumption of the good or competitive movements from elsewhere. While regression equations may accurately reflect traffic in the historic period under study, they can lead to unstable or even explosive forecasts. This kind of instability is not a problem with time series models, since no multicollinearity exists. However, the time series models may be <u>too</u> stable, and often miss turning points; this of course is due to their reliance on past patterns continuing into the future.

The third point involves the ease or difficulty of updating the models as new information becomes available. The time series models generally have built-in procedures which make this very easy. For the regression models,

however, the equations must be reestimated, scenarios for exogenous variables updated, and the two procedures combined. In general, the regression models are much more cumbersome than the time series models; besides making the former more tedious to construct, this feature increases the probability of error in econometric modelling. In general, the simpler the model, the less chance of serious mistakes.

The fourth point involves the philosophy behind forecasting. A regression model tries to develop cause and effect on the implicit assumption that causal relationships tend to persist over time. Time series models, on the other hand, tend to be of the "black box" variety: we are faced with a system, and we can see what it produces -- within certain bounds -- but we do not understand the basic causality and what happens if various components of the system change.

In practice, however, causal relations are often difficult to identify and quantify with any degree of reliability. Socio-economic systems are complex. Often two variables may be correlated, without any clear reason as to why changes in one cause changes in the other, rather than vice-versa. Furthermore, misuse of statistical techniques in the past have often led investigators to find causal relations where in fact there were none.[3]

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[3]For discussion and examples, see D.A. Pierce and L.D. Haugh, "Causality in Temporal Systems", Journal of Econometrics, 1977; D.A. Pierce, "Relations -- and the lack thereof -- between (cont'd next page)

Our limited investigations of dynamic regression analysis showed that causality, while present, seemed to be of less use for forecasting in many cases than a projection based on some form of continuation of past patterns. This is due in part to the complexity of the demand for transport; and in part to the difficulty in quantifying institutional constraints which seem to play a very important role. Nevertheless, in certain cases past trends are a poor guide to the future, and some form of causality must be sought.

In conclusion, both time series and regression models have a role to play in forecasting the demand for freight transport. It is not possible to determine optimal techniques *a priori* and, in each forecasting situation, the choice of methodology must rest in part on the insights of the investigator.

3(cont'd)
economic time series," *Journal of the American Statistical Association* 1977, C.W.J. Granger and P. Newbold, "Spurious Regressions in Econometrics," *Journal of Econometrics*, 1974.

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Chapter 1

Introduction

The purpose of this report is to describe recent work on forecasting the demand for freight transport carried out under the joint sponsorship of the Canadian Transport Commission and Transport Canada.[1] The present report is the specific response to a proposal that the methods of time series analysis and dynamic regression be used to provide forecasts of the demand for transport with particular reference to the commodity groupings Coal, Newsprint and Chemicals.

The two earlier reports concentrated on the construction of econometric models to provide a deeper understanding of the demand for transport for a variety of commodity groupings using the statistical methods of regression analysis. Alternatively the statistical methods of time series analysis provide a means of obtaining forecasts for the demand for transport based solely on the historical series of demand. These methods may also be supplemented by the methods of dynamic regression which permit the incorporation of information on related series and so provide a deeper understanding of the demand and improve the reliability of the forecasts.

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[1]Previous work has been described in Report on Transport Demand Forecasting Program: Phase One, Canadian Transport Commission, January 1975 and Report on Modelling the Demand for Freight Transport, Canadian Transport Commission, June 1976.

In chapter 2 we provide a brief technical description of the statistical methods of time series analysis and dynamic regression used in this report and based on the Box-Jenkins philosophy of time series model building. In chapter 3 we discuss some of the details and problems associated with the preparation of the data. The forecasts of the demand for freight transport of Coal are presented in chapter 4 using time series analysis and dynamic regression and are compared with the forecasts from the earlier regression models. In chapters 5 and 6 we forecast the demand for transport of Newsprint and Chemicals respectively but owing to time constraints the supplementary methods of dynamic regression were not attempted for these commodities.

Readers interested in the methodology of the project should read chapters 2 and 3 first and then proceed to the applications in the later chapters while readers primarily interested in the results should proceed directly to the chapters on the individual commodity groups, referring back to chapters 2 and 3 as required.

Chapter 2

Time Series Analysis and Dynamic Regression

In this section we provide a brief overview of the statistical methods that were used to model the monthly movements of freight, and thereby provide forecasts of future movements. The class of models considered and the process of model development is closely associated with the Box-Jenkins philosophy of time series model building[1] which we now review.

Suppose that $Z_t, Z_{t+1}, Z_{t+2}, \ldots$ represent a series of measurements recorded at equally spaced time intervals t, t+1, t+2,... and suppose that no precise or deterministic relationship exists between measurements recorded at different points in time. Nevertheless it may be possible to derive a probability or stochastic model that can satisfactorily describe the series and can be used to provide forecasts of future values of the series. An important class of stochastic models for describing time series which has received a great deal of attention in the literature is the class of ARMA (Auto Regressive - Moving Average) models given by

$$\tilde{Z}_t - \phi_1 \tilde{Z}_{t-1} - \phi_2 \tilde{Z}_{t-2} - \ldots - \phi_p \tilde{Z}_{t-p} = a_t - \theta_1 a_{t-1}$$

$$- \theta_2 a_{t-2} - \ldots - \theta_q a_{t-q}$$

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[1] Box G.E.P. and Jenkins G.M. 'Time Series Analysis: Forecasting and Control' 1976, Holden-Day. The notation used in this section is the same as in the reference.

where $\tilde{Z}_t = Z_t - \mu$ are the deviations of the series from some constant value μ. In the model the ϕ_i are the auto regressive parameters, the θ_j are the moving average parameters, and the values a_t may be regarded as a series of stochastic shocks which are assumed to be independently distributed $N(0,\sigma^2)$.

An alternative representation of the class of ARMA models employs the backward shift operator B which is defined by $BZ_t = Z_{t-1}$ so that $B^m Z_t = Z_{t-m}$. Then the model may be written

$$\varphi(B)\ \tilde{Z}_t = \theta(B)\ a_t \tag{2.1}$$

where the autoregressive operator $\varphi(B)$ is given by

$$\varphi(B) = 1 - \phi_1 B - \phi_2 B^2 - \dots - \phi_p B^p$$

and the moving average operator $\theta(B)$ is given by

$$\theta(B) = 1 - \theta_1 B - \theta_2 B^2 - \dots - \theta_q B^q$$

Provided that the characteristic equation $\varphi(B) = 0$ has all its roots lying outside the unit circle, equation (2.1) defines a stationary time series model which supposes that the series remains in equilibrium or in a steady state about the constant level μ. However, many time series examined in forecasting applications are often better represented as

Non-Stationary. If some of the roots of $\varphi(B) = 0$ lie inside the unit circle then the corresponding time series will exhibit explosive Non-Stationary behaviour which is not suitable for the type of applications we are considering. The other case open to us within this framework is that for which some of the roots of $\varphi(B) = 0$ lie on the unit circle: it turns out that the resulting Homogeneous Non-Stationary time series models are very suitable for representing business and economic time series which may be characterised by shifts in level and slope. If we therefore assume that $\varphi(B)$ is a Non-Stationary autoregressive operator such that d of the roots of $\varphi(B) = 0$ are unity and the remainder lie outside the unit circle, then we may write

$$\varphi(B) = \phi(B)\,(1 - B)^d = \phi(B)\,\nabla^d$$

where $\phi(B)$ is a Stationary autoregressive operator and $\nabla = 1 - B$ is the backward difference operator. Since $\nabla^d \tilde{Z}_t = \nabla^d Z_t$ for $d \geq 1$ we can rewrite equation (2.1) as

$$\phi(B)\,\nabla^d Z_t = \theta(B)\,a_t$$

which defines the class of ARIMA (Auto Regressive-Integrated-Moving Average) models.

It is sometimes useful to consider a slight extension of the ARIMA model by including a deterministic trend parameter θ_o

$$\phi(B)\ \nabla^d\ Z_t = \theta_o + \theta(B)\ a_t \tag{2.2}$$

If we write $W_t = \nabla^d\ Z_t$ then the inclusion of θ_o is equivalent to permitting W_t to have non-zero mean, so that an alternative way of expressing the more general model (2.2) is

$$\begin{aligned} \phi(B)\ \tilde{W}_t &= \theta(B)\ a_t \\ \tilde{W}_t &= W_t - \mu \\ W_t &= \nabla^d\ Z_t \end{aligned} \tag{2.3}$$

The process of developing a model such as (2.3) for a particular observed time series is achieved by a three stage iterative procedure based on Identification, Estimation and Diagnostic Checking. The Identification stage incorporates the methods by which the orders of the autoregressive and moving average operators, p and q respectively, and the degree of differencing d, are tentatively determined by examination of statistics relating to the observed time series and in particular the sample autocorrelation at lag k

$$r_k(z) = \frac{\sum_t (z_t - \bar{z})(z_{t+k} - \bar{z})}{\sum_t (z_t - \bar{z})^2}$$

At the Estimation stage we adopt well known statistical techniques to make inferences from the data, about the parameter ϕ_i, θ_j, μ and σ^2, conditional on the adequacy of the model tentatively under examination. At the stage of Diagnostic Checking, we check the fitted model and its relationship to the data, with the intention of revealing model inadequacies. This involves an examination of the residuals $\hat{a}_t$ from the model and in particular the sample autocorrelation function of the residuals at lag k, $r_k(\hat{a})$. In addition a global assessment of model inadequacy may be obtained upon examination of $\sum_k r_k^2 (\hat{a})$ which, apart from a scale factor, follows approximately the χ^2-distribution.

This process of model development continues, enabling the model to be improved, until such time as it is judged adequate at the Diagnostic Checking stage. Lastly we use the proposed model to forecast future values of the observed time series and to provide confidence limits on those forecasts.

Some of the monthly movements of freight that we are considering exhibit marked seasonal patterns. We say that a series exhibits periodic behaviour with period s when

similarities in the series occur after s basic time intervals: in the applications we are considering s will frequently be 12. The seasonal pattern implies that an observation for a particular month, say April, is related to the observations for previous Aprils. Suppose Z_t is the observation for the month of April; then we might be able to link this observation with observations in previous Aprils by a model of the form

$$\Phi(B^s)\ \nabla_s^D\ Z_t = \Theta(B^s)\ \alpha_t \qquad (2.4)$$

where $\nabla_s = 1 - B^s$ and $\Phi(B^s)$, $\Theta(B^s)$ are polynomial operators in B^s of degrees P and Q respectively. Similarly the model might be used to link the current behaviour for March with previous March observations and so forth: moreover, it would be usual to assume as a first approximation that the parameters Φ and Θ contained in these monthly models would be the same for each month. Now the error components α_t in these models would not in general be unrelated and we may take account of these relationships by introducing a second model

$$\phi(B)\ \nabla^d\ \alpha_t = \theta(B)\ a_t \qquad (2.5)$$

where a_t are now regarded as a series of stochastic shocks independently distributed $N(0,\sigma^2)$ and $\phi(B)$, $\theta(B)$ are polynomial

operators in B of degree p and q respectively. Combining (2.4) and (2.5) we obtain a multiplicative seasonal time series model

$$\phi(B)\ \Phi(B^s)\ \nabla^d\ \nabla_s^D\ Z_t = \theta(B)\ \Theta(B^s)\ a_t$$

Once again this model can be extended to include a deterministic trend and may be expressed as

$$\phi(B)\ \Phi(B^s)\ \tilde{W}_t = \theta(B)\ \Theta(B^s)\ a_t$$

$$\tilde{W}_t = W_t - \mu \qquad (2.6)$$

$$W_t = \nabla^d\ \nabla_s^D\ Z_t$$

and it is this general model that was used to model monthly freight movements and subsequently to forecast future values of the time series.

Two remaining practical problems that have received some attention[2] are the problems of i) modelling series which

[2] Brubacher S.R. and Tunnicliffe Wilson G. (1976) "Interpolating time series with application to the estimation of holiday effects on electricity demand", Appl. Statist. 25, 107-116

Chatfield C. and Prodhero D.L. (1973) "Box-Jenkins seasonal forecasting: problems in a case study" J.R. Statist. Soc. A, 136, 295-336.

contain extreme or outlying observations due to such diverse causes as industrial or transportation strikes, extreme weather conditions or recording errors and ii) selecting the appropriate metric in terms of which the time series can most suitably be modelled i.e., selecting an appropriate non-linear transformation of the data. The analyses carried out in this report used the data without taking into account the occurrence of the occasional outlying observation and the only transformations of the data from their original units were linear transformations such as a change of scale. This was not the ideal approach, particularly regarding the outlying observations, but was imposed because of time constraints and the lack of the appropriate computer software.

In the models we have discussed so far, we are attempting to forecast a time series using only information obtained from the time series in the past. In time series forecasting there arises the question as to whether it would be useful to consider a related series X_t when forecasting a series Z_t. Forecasts of Z_t may be considerably improved by using information from some associated series X_t, particularly if changes in Z tend to be anticipated by changes in X (in such cases X is termed a leading indicator for Z). A class of stochastic models for describing the relationship between two associated time series is the class of Dynamic Regression models given by

$$Z_t = \delta^{-1}(B)\ \omega(B)\ X_{t-b} + N_t$$

where the Dynamic Regression or Transfer Function, as it is frequently referred to, is represented by the ratio of the two polynomial operators

$$\delta(B) = 1 - \delta_1 B - \delta_2 B^2 - \ldots - \delta_r B^r$$

$$\omega(B) = \omega_0 - \omega_1 B - \omega_2 B^2 - \ldots - \omega_s B^s$$

operating on the leading indicator lagged by b time intervals, and the Noise component N_t is represented by an ARIMA model. Such models can readily be generalised to include more than one leading indicator.

The process of developing a dynamic regression model between particular observed time series is achieved by a five step iterative procedure as follows:

i) Derivation of an appropriate ARIMA model for X_t.

ii) Preliminary identification and estimation of the Dynamic Regression parameters δ_i, ω_j and b.

iii) Derivation of an appropriate ARIMA model for the preliminary estimates of the noise N_t.

iv) Final simultaneous estimation of all parameters.

v) Checking the fitted model in its relation to the data with intent to reveal model inadequacies.

It has been claimed recently[3] that this process of developing a dynamic regression model frequently fails to proceed further than step (ii) owing to a lack of any significant statistical relationship remaining between Z_t and X_t, after accounting for the information contained in the past history of the series themselves. Attempts in this study to develop Dynamic Regression models between monthly movements of coal and a variety of supposedly related economic indicators gives further supporting evidence to this claim as we shall see in §4 although significant Dynamic Regression models have been developed in some instances.

Throughout §4, §5 and §6, whenever ARIMA and Dynamic Regression models are specified, all parameter estimates given will be statistically significant and the values in parentheses beneath each parameter estimate will represent the 95% confidence limits for that parameter estimate.

[3] Pierce D.A. (1977) "Relationships - and the lack thereof - between Economic Time Series, with special reference to Money and Interest Rates" J. **Amer. Statist.** Assoc. 72, 11-26

Chapter 3

Data Preparation

Data files on monthly origin-destination traffic flows by rail and marine modes and for different links were constructed. The links represented shipments among the 5 Canadian regions and between Canada and the U.S. and other foreign geographical areas such as Western Europe, Japan and Latin America. In addition, a small file was created for the few structural variables, representing mostly Canadian economic activities, used for the dynamic regression phase of the study. The monthly data was based mainly on Statistics Canada sources for Canadian regions and on some U.S. and foreign publications. All flows were reported in short tons scaled by appropriate factors.

3.1 Rail Shipments

(i) Exports -- These were primarily the shipments to the U.S. from the 5 Canadian regions. The monthly data from the External Trade Division of Statistics Canada was used to produce the flows. The publications gave exports by mode and by region of lading, were accessible on tape from January 1966 to December 1975 and were considered to be statistically reliable. Previously these links used data computed from the Statistics Canada publication, 52-205 "Railway Freight Traffic" (RFT). The RFT data exists on an annual basis and does not identify the true origins of lading. The formula:

(Region i to U.S.) = (Delivered to U.S.) - (Received from U.S. destined for U.S.)

is correct for region i only if "delivered to U.S." does not contain freight transhipped from other regions and freight "received from U.S. destined for U.S." returns to the U.S. via region i. Unfortunately transhipments do occur especially in the case of Newsprint. The RFT data was therefore superseded by the External Trade Data.

ii) Domestic Shipments -- The maximum of 25 intra-regional and inter-regional rail links were based on the Waybill Analysis compiled yearly by the Canadian Transport Commission and on the RFT file: the waybill sample exists, on computer tape, from January 1957 to December 1976.

In the past, the annual flows, V_{gt}, from the 1% waybill sample for a commodity g in year t were adjusted by the total domestic unloadings, W_{gt}, as derived from the RFT file, the adjustment factor, F_{gt}, being defined as

$$F_{gt} = W_{gt}/V_{gt}$$

Unfortunately, aggregations of the adjusted flows into regional loadings and unloadings differed significantly from those

computed from the RFT file. In many instances neither loadings nor unloadings agreed. Typical examples of these discrepancies at the regional level were found in the case of Coal shipments: movements in the Atlantic provinces were grossly underadjusted while those in the Western provinces tended to be overadjusted.

In order to minimize this problem of regional inconsistencies, an alternative method was adopted for the time series analysis. This involved a more detailed study of the RFT file in conjunction with some other sources of information, such as the Canadian Minerals Yearbook in the case of Coal. This made possible the calculation of "net flows" to and from each province or region and, given prior knowledge about areas of production and locations of major markets, it was then possible to deduce the 100% annual data for the more important links.

The Waybill sample was then used to indicate the presence or absence of significant flows on certain links and, as a last resort, to resolve some of the smaller flows. Once the annual data was obtained, the monthly flows were extracted from the Waybill sample and adjusted upwards to reflect the correct annual total. This procedure was applied to produce the Coal domestic rail flows. Regional aggregations now compared favourably with the loadings and unloadings from the

RFT file. To further improve the consistency, the estimated annual flows and the RFT loadings and unloadings were used as "good initial conditions" and "weights" in a version of a numerical procedure called Quadratic Programming provided by Statistics Canada. The program uses Lemke's quadratic algorithm to deduce intra-regional and inter-regional flows with the loadings and unloadings acting as boundary conditions. This technique was tested for Coal flows from 1957 to 1976. The algorithm provided acceptable results in all cases in which it was tested and the majority of computed regional loadings and unloadings agreed with those from the RFT file to within 1% while a few "worst cases" differed by no more than 5%.

iii) Imports -- Rail import flows come principally from the United States. Since the External Trade data does not identify imports by mode and since the RFT files gave only annual data, monthly import flows by rail were not available. Monthly import data by unknown mode from External Trade existed on computer tapes from January 1966 to December 1975 and these were used for the time series analysis. Conceivably, some kind of typical rail monthly flow pattern in a representative year could be applied to the RFT data for each link. However, there is a problem of reconciliation with the marine and trucking modes such that total imports will be consistent with those reported. Moreover, the RFT data does not reveal the true

destinations of the freight. However, once forecasts on projections are made of the import movements, it might be possible to apportion the annual figures to the various modes based, perhaps, on a percentage share reflecting historical trends.

3.2 Marine Shipments

i) Exports -- Monthly export data from the External Trade Data file were used for all marine shipments to the U.S. and foreign regions: the observed period extended from January 1966 to December 1975. This data source replaced previous sources such as the Shipping Statistics, National Harbours Board and St. Lawrence Seaway data.

ii) Domestic Shipments -- Monthly domestic flows from January 1965 to December 1975 were processed from the Statistics Canada Shipping Statistics computer tapes. The files were known to contain errors and the overall quality of the data was questionable. However, it was the only source that claimed to record all marine domestic movements. For the earlier regression model, the Annual Shipping Statistics data were subject to modification by the St. Lawrence Seaway data (1963-1972) and by the National Harbours Board data (1965-1972). This procedure was not applied to the marine flows used in this study. The NHB data extends up to 1972 only and contains only

annual activity figures (inward and outward movements). The Seaway data, although considered fairly good, is necessarily incomplete. It does exist on a monthly basis but was not updated and is more difficult to process than the Shipping Statistics file because of the nature of the data records. It was felt that the marginal improvement which the NHB and Seaway data might produce did not merit the time and effort that would have been required to extract and adjust the monthly information.

iii) Imports -- The monthly import flows from External Trade were used. As mentioned before, this source does not identify imports by mode. The Shipping Statistics file does give monthly marine inflows to the Canadian regions from the U.S. and foreign regions but the dubious nature of the statistics on shipments of low volume heterogeneous commodity groupings, such as Chemicals, discouraged its use. In the present study, the problem of distinguishing import modes resolved itself in many instances. For example, there were no Newsprint imports. Generally, freight from off shore geographical areas were carried by water. For Coal, there was only one significant import link, namely U.S. to Ontario, and flows along this link were known to be approximately 95% by marine mode.

3.3 Truck Shipments

The trucking mode was not considered in this study. The External Trade data does provide monthly transborder movements by road, however trucking of Coal to the U.S. is insignificant while shipments of Newsprint by road, from Quebec and Ontario are small, being less than 7% of the total movements. The volume of Chemicals carried annually by truck to the U.S. was low (500,000 tons) but was however comparable to that moved by marine. Apart from the External Trade source, very little trucking data is available . The For-Hire trucking survey, condicted by Statistics Canada, gives annual origin-destination flows by commodity from 1970-1974. Although the figures for 1973 and 1974 seemed adequate, the accuracy of the first three surveys was not considered good. Thus, the rather scanty information on domestic trucking activities hindered analysis of freight flows using this mode.

Chapter 4

The Transportation of Coal

4.1 Analysis

In keeping with the quantitative nature of this report, we shall construct a general description of the supply and demand characteristics of the Canadian Coal Industry from readily available sources of statistical information. This general structure will serve as a basis of comparison with published information from Coal Industry sources and elsewhere. Arising from this analysis some of the important issues relating to the transportation of Coal from region to region may be determined and these will serve as a basis for judging the reliability of statistical information concerning Coal movements and the associated forecasts.

In Tables 4.1 and 4.2 we have outlined the Principal Supply and Demand Components for Coal in thousands of short tons for 1968 and 1974. The supplies of Coal, in excess of 100,000 short tons, were detailed by region of origin and type of coal: the four major classes of coal are Anthracite (AN), Bituminous (BIT), Subbituminous (SUBBIT) and Lignite (LIG). Also included were any large increases or decreases to recorded inventories (INV). The disposition of coal was detailed by region and by type of demand, for usage in excess of 100,000 short tons: the major types of demand for coal

Table 4.1: Principal Supply and Demand Components for Coal in 1968 in thousands of short tons

DEMAND \ SUPPLY		ATL BIT	US-ATL BIT	ATL INV	US-QUE AN	US-QUE BIT	US-ONT AN	US-ONT BIT	ONT INV	SASK LIG	ALTA BIT	ALTA SUBBIT	BC BIT
	TOTALS	3,930	526	336	290	526	176	15,802	-112	2,250	948	2,977	903
ATL-ELEC	1,119	593	526										
ATL-COKE	726	391		336									
ATL-IND	293	293											
ATL-DOM	242	242											
ATL-COM	145	145											
ATL-US-EXP	150	150											
ATL-UNACC	138	138											
QUE-COKE	361					361							
QUE-IND	1,295	820			290	165							
ONT-ELEC	6,611							6,723	-112				
ONT-COKE	6,066							6,066					
ONT-IND	3,363	1,038						2,169		159			
ONT-DOM	180						176						
ONT-COM	460							460					
ONT-MARINE	205							205					
ONT-UNACC	235							235					
PRA-ELEC	4,034									2,091		1,943	
PRA-IND	377										139	157	170
PRA-DOM	492											492	
PRA-RAIL	115											115	
PRA-UNACC	153											153	
BC-COKE	234												234
BC-JAP-EXP	1,283										809		450
BC-IND	115												

1. Compiled from Statistics Canada, 26-206, 'Coal Mines 1968', and 52-505, 'Detailed Energy Supply and Demand in Canada 1958-1969.
2. All entries less than 100,000 short tons have been omitted.

Table 4.2: Principal Supply and Demand Components for Coal in 1974 in thousands of short tons

DEMAND \ SUPPLY		ATL BIT	US-ATL BIT	US-QUE AN	US-QUE BIT	QUE INV	US-ONT BIT	ONT INV	SASK LIG	ALTA BIT	ALTA SUBBIT	BC BIT
	TOTALS	1,825	194	306	249	132	12,783	2,155	3,842	3,651	5,595	8,532
ATL-ELEC	990	878	112									
ATL-COKE	724	642										
QUE-COKE	289					132						
QUE-IND	462	108		105	249							
QUE-UNACC	139			108								
ONT-ELEC	7,409						5,352	2,007				
ONT-COKE	7,051						6,809			174		
ONT-IND	622						622					
ONT-US-EXP	148							148				
PRA-ELEC	8,603								3,842		4,761	
PRA-IND	388										388	
PRA-UNACC	184										184	
BC-COKE	234											234
BC-JAP-EXP	10,976									3,171	160	7,507
BC-US-EXP	231									231		
BC-OTHER-EXP	442										102	300
BC-UNACC	477											477

1. Compiled from Statistics Canada, 26-206, 'Coal Mines 1974' and 52-207, 'Detailed Energy Supply and Demand in Canada 1974'
2. All entries less than 100,000 short tons have been omitted.

were for electrical generation (ELEC), the making of coke used in blast furnaces for steel production (COKE), general industrial use (IND), export (EXP), Domestic Consumption (DOM), Commercial Consumption (COM) and Transportation (RAIL and MARINE). Also included were quantities of coal officially indicated as unaccounted for (UNACC).

Regarding the preparation of data in the Tables, several points are worthy of note. Owing to the omission of supplies of coal or consumption of coal less than 100,000 tons, and the lack of complete agreement between the published statistics, the totals of rows and columns are not always equal to stated totals. Moreover, the lack of detailed information in the Statistics Canada sources makes it impossible to allocate some supplies to a particular type of use with any degree of certainty: this is particularly true of the changes in inventories. One of the reasons for the discrepancies in published production figures is the tremendous volumes of plant waste that are produced at the preparation plants: in 1974 a total of 4,261,352 short tons were recorded as plant waste, 16% of Canadian raw coal production[1]. Furthermore, discrepancies are introduced during transportation, and

[1] Statistics Canada: 45-002 'Coal and Coke Statistics' December 1974.

stockpiling between figures reported by coal mine operators, the railways and External Trade documents: for example stocks may become contaminated with quantities of moisture thereby increasing recorded volumes.[2]

We now proceed to outline the major trends indicated by the Tables and to provide supporting evidence from industry and government sources. On the demand side, Coal is principally used for the generation of electricity, the making of coke and for export. A comparison between 1968 and 1974 shows a decline in the number of different ways in which coal is put to use in significant quantities, despite an increase in consumption over the period from 28,392,000 to 39,370,000 short tons: in particular, coal ceased to be used in significant quantities for Domestic, Commercial and Transportation purposes which reflects a shift towards alternative fuels such as oil and gas. The increase in consumption over the period was taken up by a dramatic increase in the export of coal to Japan. These trends are demonstrated in Table 4.3.

It is also apparent from an examination of Tables 4.1 and 4.2 that different types of coal are put to different uses: a summary of type of coal by use appears in Table 4.4. What is not apparent from the Tables is the tremendous

[2] These points are highlighted by the considerable volumes of coal which remain officially unaccounted for.

Table 4.3: A comparison between the ways in which coal is put to use in 1968 and 1974: figures are in percentages and derived from Tables 4.1 and 4.2.

	1968	1974
Electrical Generation	41	43
Coke Making	26	21
Export	5	30
Other	28	6
Total	100	100

Table 4.4: The four major classes of Coal and their principal uses.

Class of Coal	Use
Anthracite	Domestic Fuel. Can be blended with bituminous coal to produce an improved coking quality.
Bituminous	Domestic and Industrial Fuel. Medium to Low volatile coals used for producing coke.
Subbituminous	Used primarily for thermal electric generation.
Lignite	Used primarily for thermal electric generation.

Sources: Energy, Mines and Resources, 'Coal in Canada 1975'.

variation in the price of different types of coal, as outlined in Table 4.5. In particular, Bituminous Coal is valued much higher than Subbituminous or Lignite.

On the production side, Tables 4.1 and 4.2 indicate a marked decline in Coal production in the Atlantic Region together with a marked increase in production in Alberta and British Columbia. The decline in production in the Atlantic Region has been attributed to a variety of factors including the decline of the steel industry in Sydney, Nova Scotia, the conversion of many industrial and residential consumers to other sources of energy, and the ending of subsidies on the movement of coal by rail. Notice however that despite the decline in the steel industry in Sydney, the demand for coal for making coke in the Atlantic Region remained virtually unchanged between 1968 and 1974. Moreover, recent reports[3] indicate a resurgence in coal mining in Nova Scotia in order to substitute coal for high-cost imported oil which is currently being used to generate 68% of its electric power, thereby assisting in the stabilization of provincial power rates.

The rise of Western Canadian Coal Production resulted mainly from increased demand for thermal coal within the Western Provinces and from increased off shore demand for

[3]Financial Post Special Report Feb. 1978: Coal's Comeback in Canada.

Table 4.5: The valuation of coal by type and region in 1974

	Thousands of Short Tons	Thousands of $	$ per Short Ton
ATL-BIT	1,825	29,911	16.4
ALTA-BIT	3,651	90,156	24.7
BC-BIT	8,532	153,567	18.0
ALTA-SUBBIT	5,595	20,875	3.7
SASK-LIG	3,842	8,317	2.2

Source: Canadian Minerals Yearbook 1975, 'Coal and Coke'.

Table 4.6: Japanese Domestic Coal Production and Crude Steel Production in thousands of short tons 1968-1974

	Domestic Coal Production	Crude Steel Production
1968	51,025	76,058
1969	48,047	95,947
1970	42,258	101,878
1971	34,980	97,506
1972	29,744	113,526
1973	23,078	132,319
1974	22,372	125,688

Sources: The Tex Report Ltd., Coking Coal Manual 1976
Japanese Iron and Steel Federation, Monthly reports of the Iron and Steel Industry.

coking coal for Japan. The increase in production of thermal coal took place particularly in the Lake Wabamun area of Alberta which supplies Calgary Power Ltd. The increase in off shore demand for coking coal for Japan came as a result of declining Japanese Domestic Coal Production and increased Japanese Crude Steel Production: see Table 4.6. One of the cornerstones of the Japanese Coal purchasing strategy has been to guarantee a secure supply of coal by importing coal from a variety of sources, principally the United States, Australia and Canada. The United States has higher-priced coal, but does not have as great a problem as Canada or Australia with coal development in inland regions involving huge investments in infrastructure. Canada's share of the market rose between 1970 and 1975 from 8.9% to 18.9%[4] and the sale of coal to the Japanese has been characterised by long-term contracts, at specified coal volumes, and specified prices per fiscal year: escalation clauses provide for renegotiation of these coal agreements. However the future of this market is no longer clear: recent reports[5] indicate that 'the severe slump in Japan's steel and general industrial situation has proved a major setback to the coal-producing provinces of Western Canada' and ' during the current fiscal year they will take as much as 15 to 20% less

[4]The Tex Report Ltd. Coking Coal Manual 1976
[5]World Coal Feb. 1978: Market Developments

than the contracted amount. This shortfall exceeds the buyer's option to vary by only 10% (or 5% in some cases)'.

The overall market for coal in Canada has only a few coal producers and a few coal consumers. In 1975 just 18 coal companies produced approximately 98% of the total Canadian Raw Coal Production while 87% of the total disposition of coal in Canada was accounted for by 8 electric power corporations, 8 coke and steel-making companies and the Japanese steel consortium[6]. As a result we are considering a market which is imperfectly competitive where the actions of a few buyers and sellers can have a perceptible influence. This is demonstrated by the dramatic increase in the export of coal to Japan during the period 1968-74 due to the efforts of the Japanese steel consortium. Furthermore, Ontario Hydro began in 1973 to plan for a supply of thermal coal from Western Canada: the program has progressed to where shipments between Western Canada and Ontario are expected to rise to 4 million tons annually by 1980[7] while shipments prior to 1970 were only of the order of 1/4 million tons annually. How Ontario Hydro's more recent committment to the purchase of long term supplies of uranium for its nuclear power plants will affect the use of coal for electric generation is uncertain.

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[6] Canadian Minerals Yearbook 1975: Coal and Coke

[7] Coal Canada <u>3</u> Feb. 1978.

The oligopsonistic structure of the coal industry makes the forecasting of coal movements in the long run very hazardous. The underlying assumptions of the statistical forecasting methods adopted in the study suppose that the coal movements are in a 'steady state' in that past trends may be expected to continue into the future: but as we have demonstrated this 'steady state' can be appreciably disturbed by the actions of a few buyers or sellers. This fact must be borne in mind when we examine the forecasts.

Some other detailed points are worthy of mention. Tables 4.1 and 4.2, showing annual figures, cannot provide any insight into the problems associated with the seasonality of transportation, particularly marine transport, the problems of peak flows, and the effects of prolonged strikes in the transportation sector: for investigation into these matters monthly data is more suitable. However the large and variable size of inventories means that stockpiling may very well smooth out consumption patterns while transportation flows may be considerably erratic on a monthly basis.

From Tables 4.1 and 4.2 annual flows of coal between regions may be estimated. In some instances, particularly with movements of coal within the Prairie region, there appears large discrepancies between these estimates and estimates obtained from other sources. This can probably be attributed to large

volumes of coal being consumed in electric generating stations adjacent to the mine site: one example of this is Calgary Power Ltd. in the Lake Wabamun area of Alberta.

We now proceed to a detailed analysis of coal movements from region to region. As indicated in §3 the movement of coal by truck has not been included although it is understood that shipments of Coal by truck are made in the Prairie Provinces sometimes to points 400 miles away. Note that throughout the following analysis, a ton refers to a short ton of 2,000 pounds.

4.2 Rail Movements of Coal within the Atlantic Provinces.

Data on monthly rail movements of Coal within the Atlantic Provinces from January 1957 to December 1976 in thousands of tons were compiled and appear in Figure 4.1 from January 1966 onwards: notice the several large erratic movements which appear to be outliers. If Z_t represents the movement during month t in millions of tons then Z_t may be described by a multiplicative seasonal time series model[1]

$$(1 - \underset{(\pm 0.128)}{0.184}\, B^2)\tilde{W}_t = (1 - \underset{(\pm 0.034)}{0.914}\, B^{12})a_t$$

$$\tilde{W}_t = W_t + \underset{(\pm 0.0045)}{0.010}$$

where $W_t = \nabla_{12} Z_t$ and the residual standard error is estimated to be 0.157. Diagnostic checks applied to the residuals from this model indicate a significant value of the autocorrelation function at lag 15 and marginally significant periodic non-randomness; the checks are not however sufficiently severe to warrant rejection of the model. The model indicates that the series is homogeneous non-stationary in its seasonal component and also contains a negative, or downward sloping trend: monthly forecasts to December 1985 using this model, together with their 75% confidence limits, also appear in Figure 4.1.

The downward trend in the forecasts is in accord with the decline in the Coal Industry in the Atlantic Provinces over the full period from 1957 to 1976 and runs counter to a slight upswing in 1975 and 1976 and to recent suggestions of a resurgence in the coal industry. The potential increases in production expected to supply the Coal fired Electrical generating station at Lingan would probably not affect the rail network as the station is close to the mine site. However the potential use of a coal-oil mixture at some generating stations, to reduce dependence on imported oil,

[1]For details of notation see Chapter 2: the numbers in parentheses indicate 95% confidence limits as mentioned previously.

which might involve the substitution of coal for oil by as much as 50% by volume, would involve the transportation network, and is expected to come on stream in the early 1980's. The total impact of these changes in the market for Coal on the transportation system is however unclear. The seasonal pattern indicates fewer movements during the summer months which is possibly due in part to a reduction in the mining operations during the holiday season.

The data and forecasts, on an annual basis, are given in Table 4.7 and are compared with data and forecasts from the earlier regression model in Figure 4.2. Forecasts from the two models are similar except that the regression model predicts an upturn starting in 1981.

Table 4.7: Annual rail movements of Coal within the Atlantic Provinces in thousands of tons: the forecasts were derived from the Time Series Model

Year	Data	Year	Forecasts
1957	4,765	1978	2,120
58	4,730	79	2,000
59	4,350	80	1,880
60	4,383	81	1,750
61	4,306	82	1,630
62	3,796	83	1,510
63	3,512	84	1,390
64	3,549	85	1,270
65	4,243		
66	4,202		
67	3,832		
68	3,301		
69	2,898		
70	2,369		
71	2,176		
72	2,065		
73	2,011		
74	2,586		
75	3,186		
76	3,367		

Figure 4.1: Monthly rail movements of Coal within the Atlantic Provinces
in thousands of tons

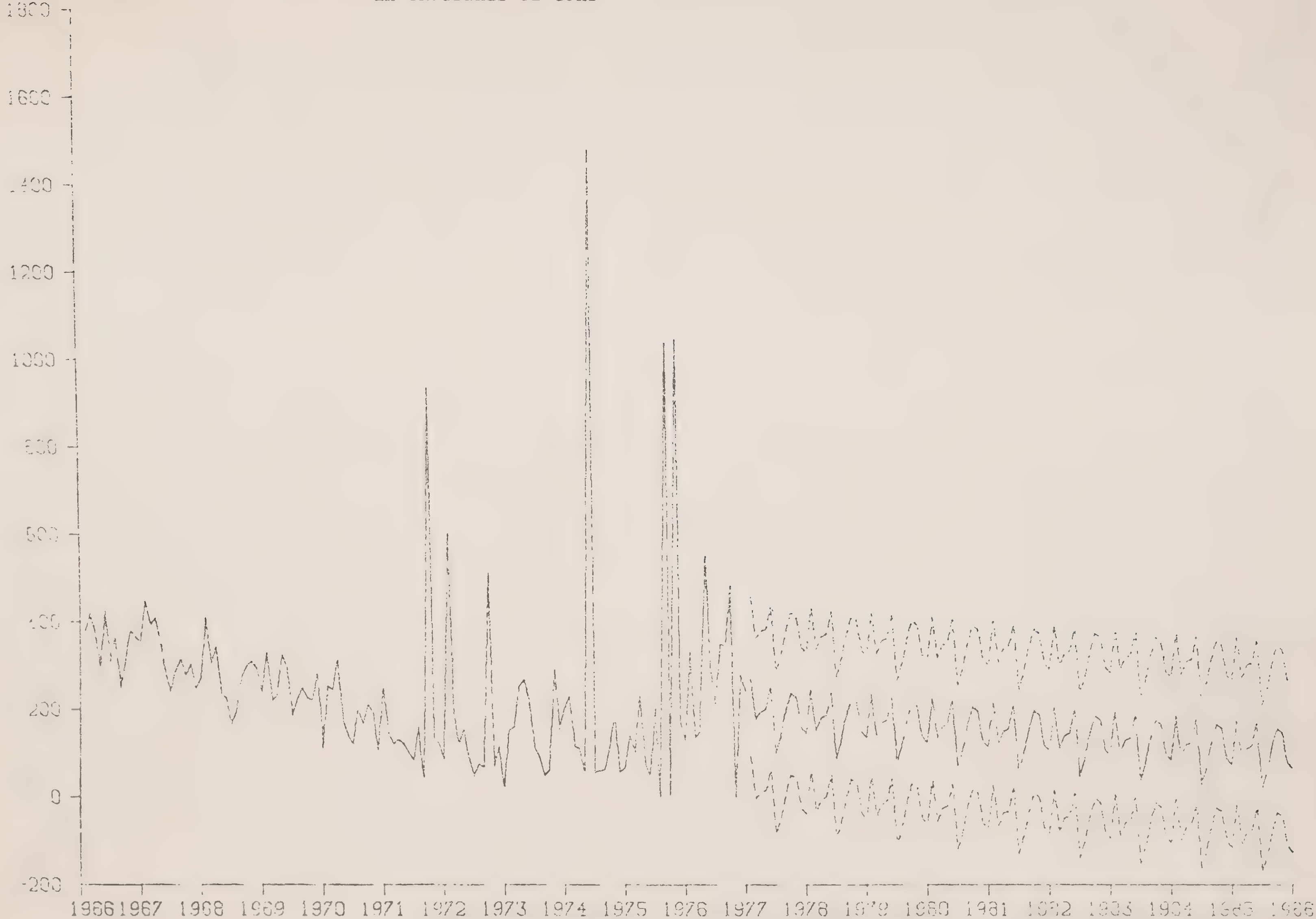
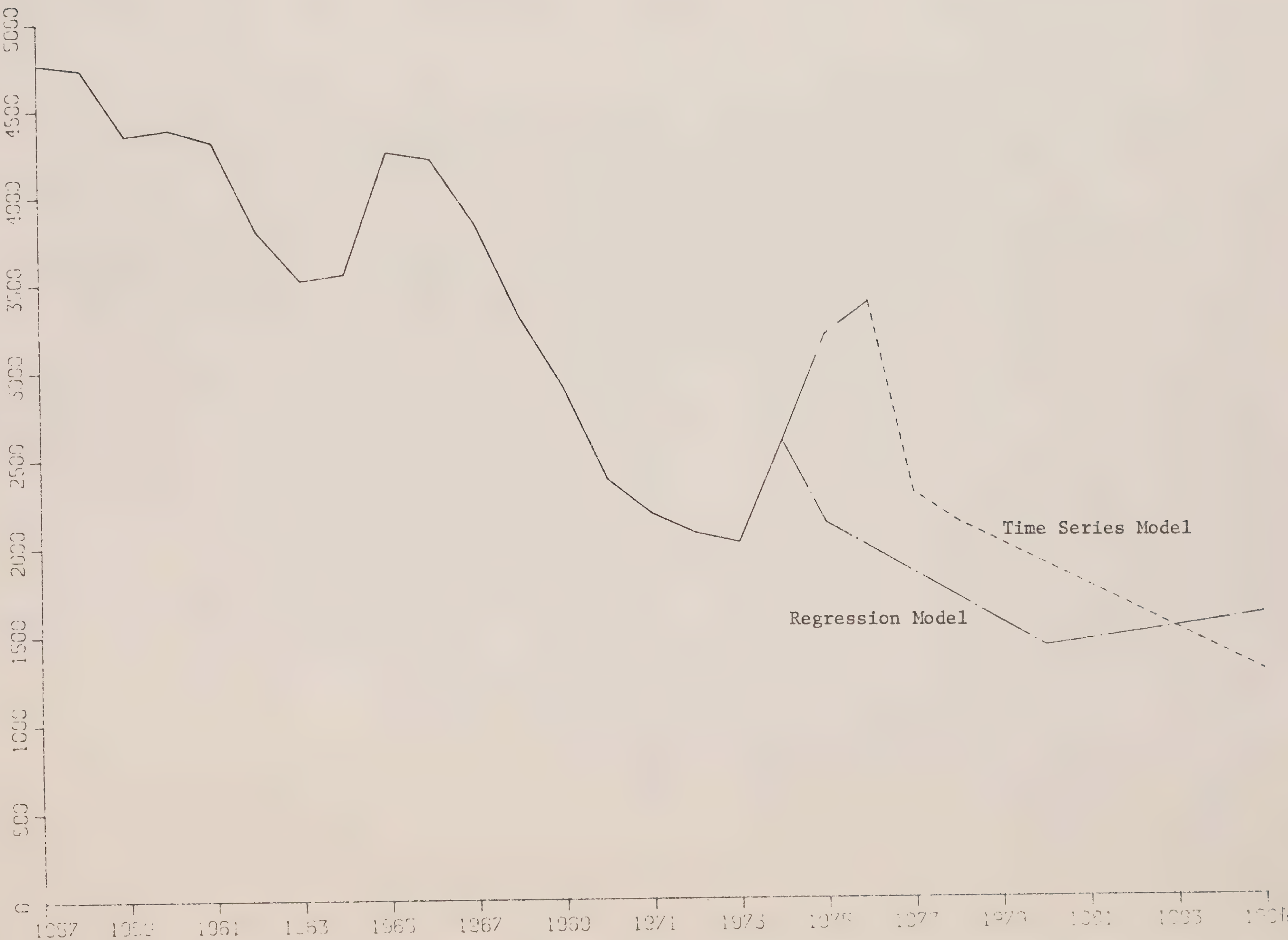


Figure 4.2: A comparison between the Regression Model and the Time Series Model for the Annual rail movement of coal within the Atlantic Provinces in thousands of tons



4.3 Imports of Coal from the United States to Quebec

Data on monthly imports of Coal from the United States to Quebec from January 1966 to December 1975 in thousands of tons appear in Figure 4.3. The mode of transport is mixed, with approximately 70% of shipments by marine mode and 30% by rail. If Z_t represents the movement during month t in millions of tons then Z_t may be described by a seasonal auto-regressive time series model

$$(1 - \underset{(\pm 0.177)}{0.398}\, B^{12} - \underset{(\pm 0.175)}{0.336}\, B^{24})\tilde{Z}_t = a_t$$

$$\tilde{Z}_t = Z_t - \underset{(\pm 0.0135)}{0.068}$$

and the residual standard error is estimated to be 0.0296. Diagnostic checks applied to the residuals from this model indicate only a significant value of the autocorrelation function at lag 22 which is insufficient evidence to reject the model. Monthly forecasts to December 1985 using the model together with their 75% confidence limits, also appear in Figure 4.3.

The seasonal component of the data is due to the closure of the St. Lawrence Seaway system during the winter months and is reflected in the forecasts. These data and forecasts, on an annual basis, are given in Table 4.8 and are compared with data and forecasts from the earlier regression model in Figure 4.4. The forecasts from the two models are noticeably different: the regression model forecasts an increase in shipments while the time series model forecasts no substantial change from current movements. The inclusion of Coal production in the United States as an explanatory variable in the regression model, and the expectation of its continued increase, led to the increase in the forecasts of Coal movements but the time series forecasts are considered to be more realistic.

Table 4.8: Annual imports of Coal from the United States to Quebec in thousands of tons: the forecasts were derived from the Time Series Model

Year	Data	Year	Forecasts
1966	954	1978	760
67	799	79	780
68	849	80	780
69	839	81	790
70	762	82	790
71	773	83	800
72	765	84	800
73	743	85	800
74	584		
75	773		

Figure 4.3: Monthly imports of Coal from the United States to Quebec in thousands of tons

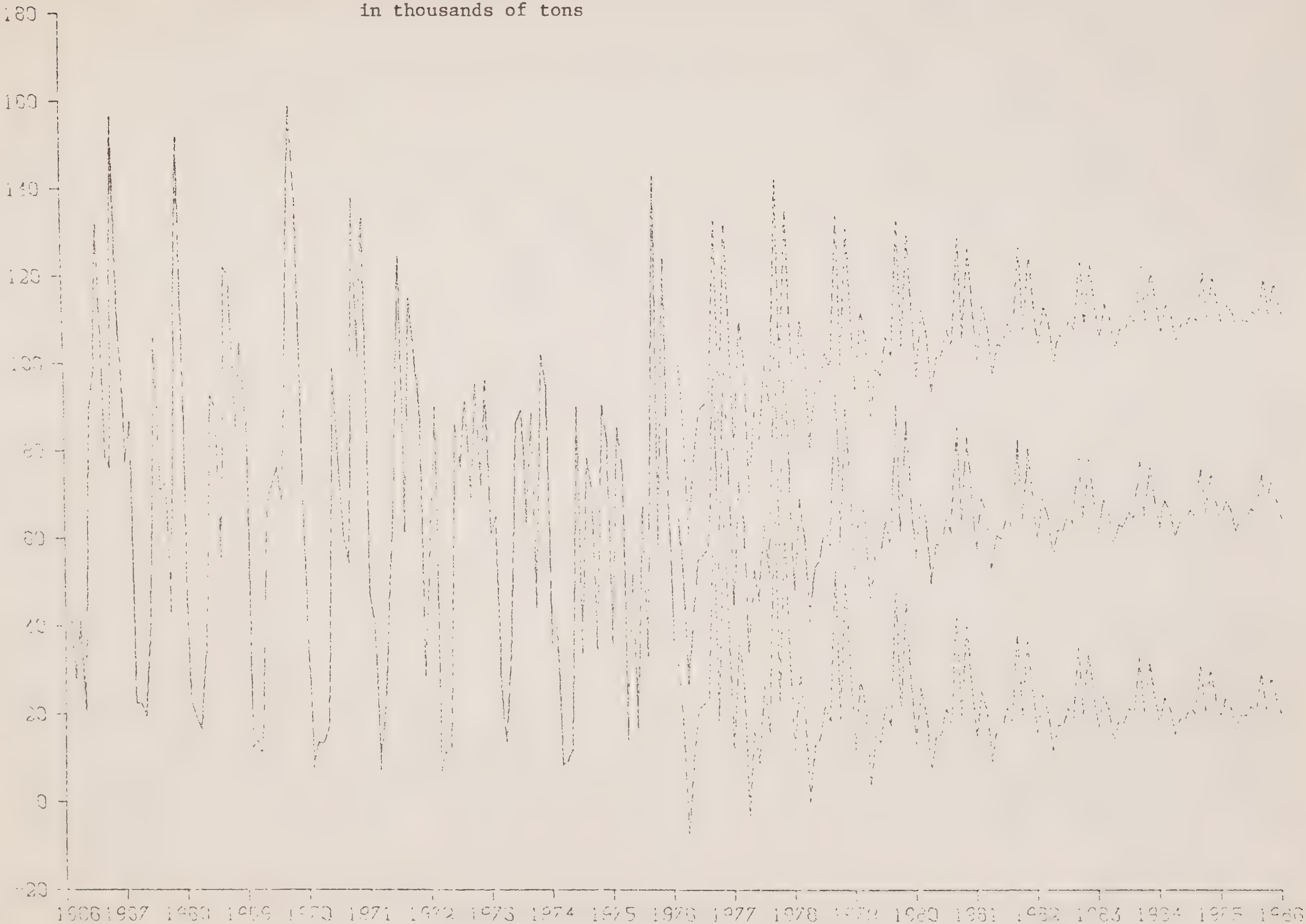
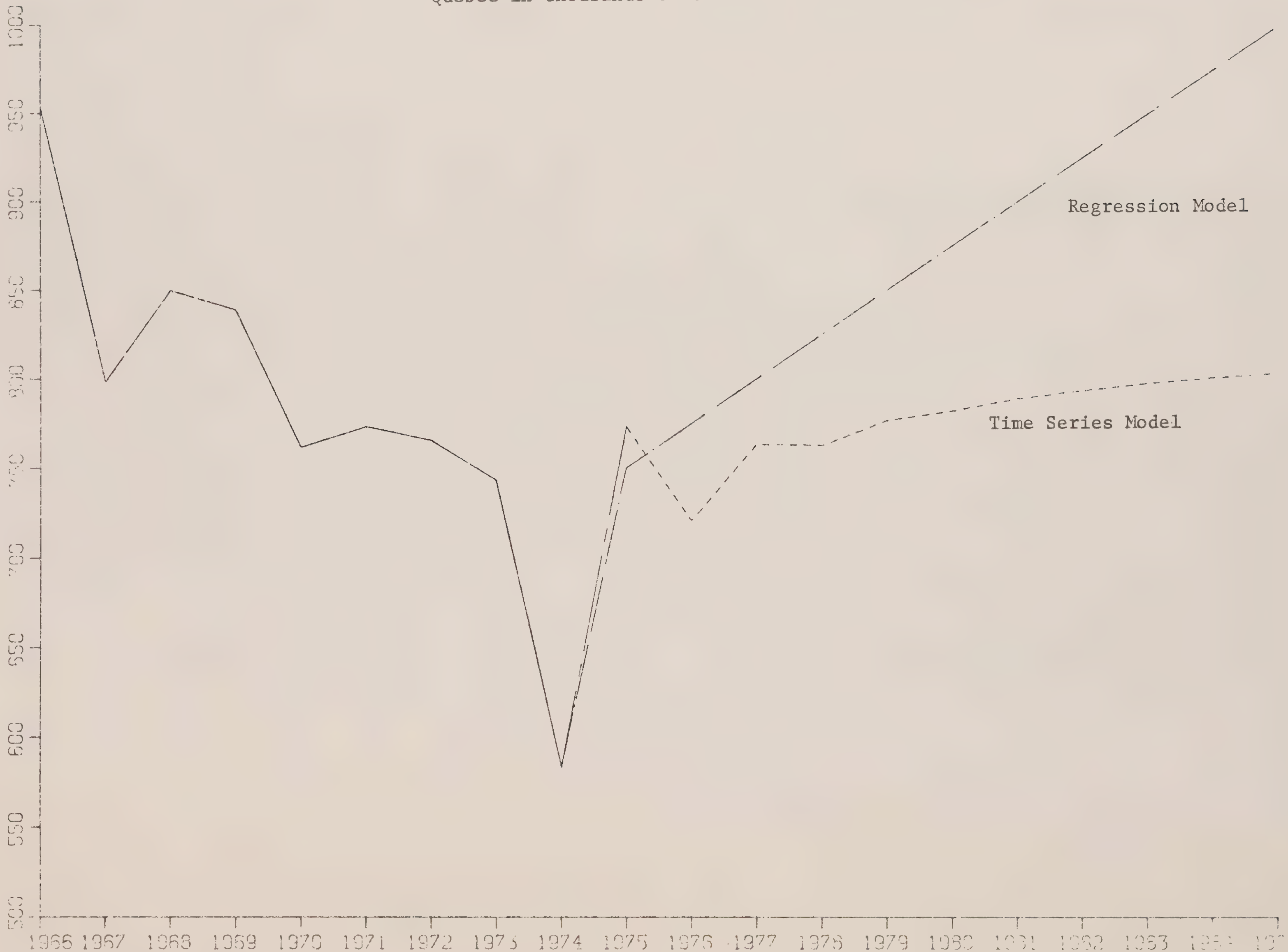


Figure 4.4: A comparison between the Regression Model and the Time Series Model for the Annual imports of Coal from the United States to Quebec in thousands of tons



4.4 Rail Movements of Coal within the Prairie Provinces

Data on monthly rail movements of Coal within the Prairie Provinces from January 1957 to December 1976 in thousands of tons were compiled and appear in Figure 4.5 from January 1966 onwards. Notice the very large movement in 1976: low rainfall in Manitoba in 1976 led to a reduction in the available power from Hydro Electric Power stations and so increased quantities of Coal were shipped from Alberta and Saskatchewan to increase capacity at Thermal Electric Power stations. If Z_t represents the movement during month t in millions of tons then Z_t may be described by a multiplicative seasonal time series model

$$\underset{(\pm 0.120)}{(1 - 0.397\,B)}\ (1 - \underset{(\pm 0.157)}{0.533}\,B^{12} - \underset{(\pm 0.155)}{0.209}\,B^{24})\tilde{Z}_t = a_t$$

$$\tilde{Z}_t = Z_t - \underset{(\pm 0.041)}{0.152}$$

and the residual standard error is estimated to be 0.0615. Diagnostic checks applied to the residuals indicate the model is not entirely satisfactory owing to significant values of the autocorrelation function at lags 3, 10 and 13 leading to a significant value of the associated χ^2 statistics. The model indicates that the series is seasonal together with a slight trend: monthly forecasts to December 1985 using this model, together with their 75% confidence limits, also appear in Figure 4.5. The seasonal pattern indicates a reduction in rail movements of Coal during the summer months which is consistent with the pattern of strip-mining operations where top soil is removed in the summer, the Coal is mined in the autumn and then transported during the winter.

These data and forecasts on an annual basis are given in Table 4.9 and are compared with data and forecasts from the earlier regression model in Figure 4.6.

The movements are not expected to be maintained at the high level of 1976 and future movements may well lie somewhere between the forecasts from the two models. Some of the expected increases in Coal production in the Prairie Provinces will involve thermal Coal for use adjacent to the mine site and will not therefore impact on the railways.

Table 4.9: Annual rail movements of Coal within the Prairie Provinces in thousands of tons: the forecasts were derived from the time series model

Year	Data	Year	Forecasts
1957	2,768	1978	1,880
58	2,493	79	1,860
59	2,131	80	1,860
60	1,756	81	1,850
61	1,493	82	1,840
62	1,555	83	1,840
63	1,271	84	1,830
64	1,257	85	1,830
65	1,447		
66	1,219		
67	1,151		
68	909		
69	626		
70	1,139		
71	882		
72	1,003		
73	903		
74	808		
75	1,397		
76	1,982		

Figure 4.5: Monthly rail movements of Coal within the Prairie Provinces in thousands of tons

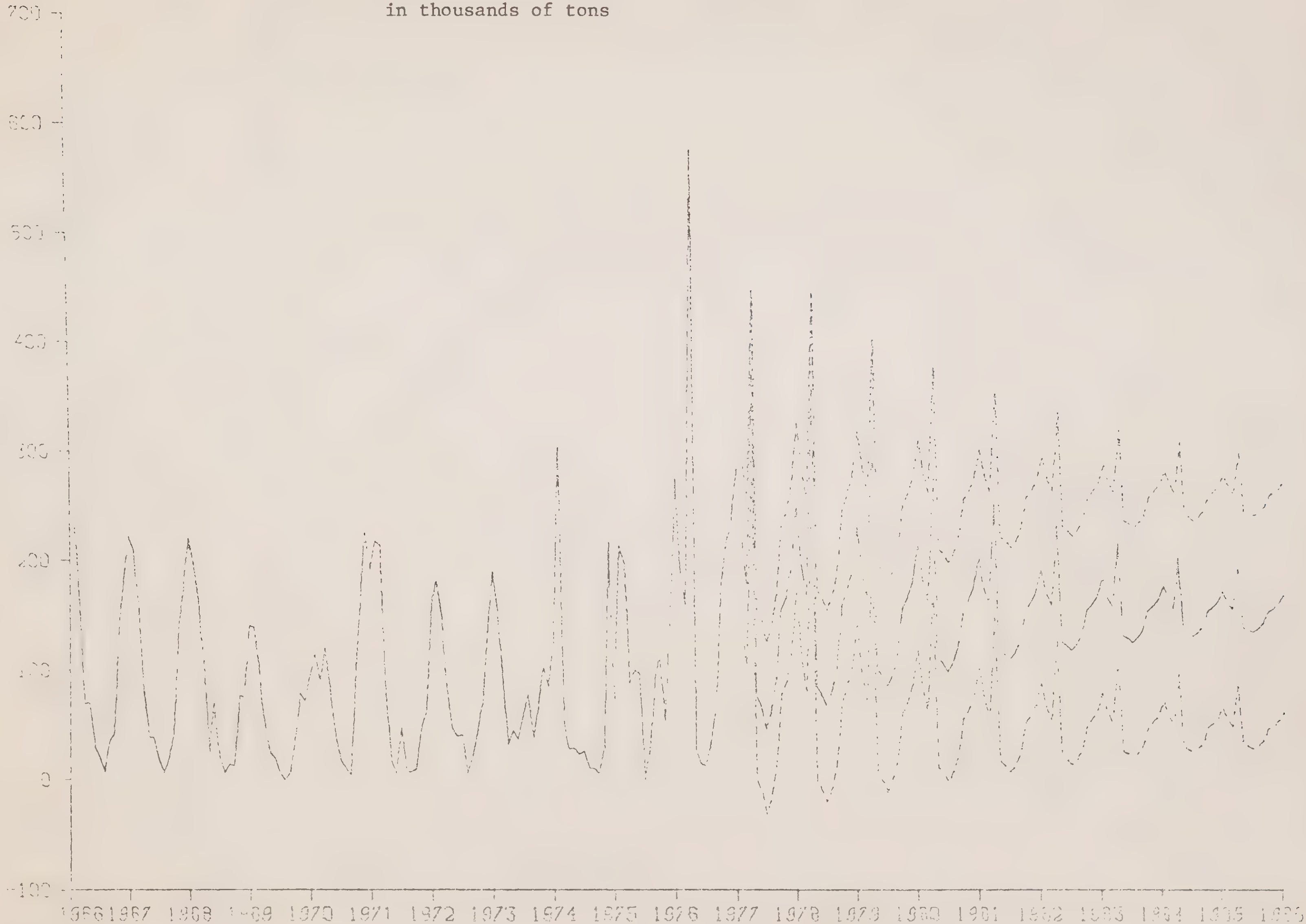


Figure 4.6: A comparison between the Regression Model and the Time Series Model for the Annual rail movement of Coal within the Prairie Provinces in thousands of tons

4.5 Rail Movements of Coal from the Prairie Provinces to British Columbia.

Data on monthly rail movements of Coal from the Prairie Provinces to British Columbia from January 1957 to December 1976 in thousands of tons were compiled and appear in Figure 4.7 from January 1966 onwards. The erratic nature of the movements may be due to the need to transport substantial quantities of Coal at short notice in response to information concerning the schedules of ships intending to carry the Coal to Japan. If Z_t represents the movement during month t in millions of tons then Z_t may be described by a multiplicative time series model

$$\tilde{W}_t = (1 - \underset{(\pm 0.020)}{0.979}\,B)\,(1 + \underset{(\pm 0.134)}{0.300}\,B^{12})a_t$$

$$\tilde{W}_t = W_t - \underset{(\pm 0.0005)}{0.002}$$

where $W_t = \nabla Z_t$ and the residual standard error is estimated to be 0.217. Diagnostic checks applied to the residuals indicate the model is not entirely satisfactory due to significant values of the autocorrelation function at lags 2, 6 and 10 leading to a significant value of the associated χ^2 statistic. The model indicates that the series is homogeneous non-stationary and has a positive, or upward sloping trend: monthly forecasts to December 1985 using this model, together with their 75% confidence limits, also appear in Figure 4.7. Since these shipments constitute a substantial proportion of the Coal that is exported from British Columbia they should be examined in the context of the export market that is discussed in greater detail in §4.10.

These data and forecasts, on an annual basis, are given in Table 4.10 and are compared with data and forecasts from the earlier Regression Model in Figure 4.8. While the overall

trends in the forecasts are similar, the differences in level may be partly attributable to the fact that the regression model was estimated from data up to 1974 while the time series was estimated from data up to 1976.

Table 4.10: Annual rail movements of Coal from the Prairie Provinces to British Columbia in thousands of tons: the forecasts were derived from the time series model

Year	Data	Year	Forecasts
1957	628	1978	4,750
58	425	79	4,970
59	612	80	5,180
60	790	81	5,400
61	676	82	5,620
62	591	83	5,840
63	711	84	6,060
64	925	85	6,270
65	870		
66	900		
67	1,003		
68	942		
69	1,000		
70	2,074		
71	3,287		
72	3,272		
73	4,053		
74	3,165		
75	4,312		
76	5,248		

Figure 4.7: Monthly rail movements of Coal from the Prairie Provinces to British Columbia in thousands of tons

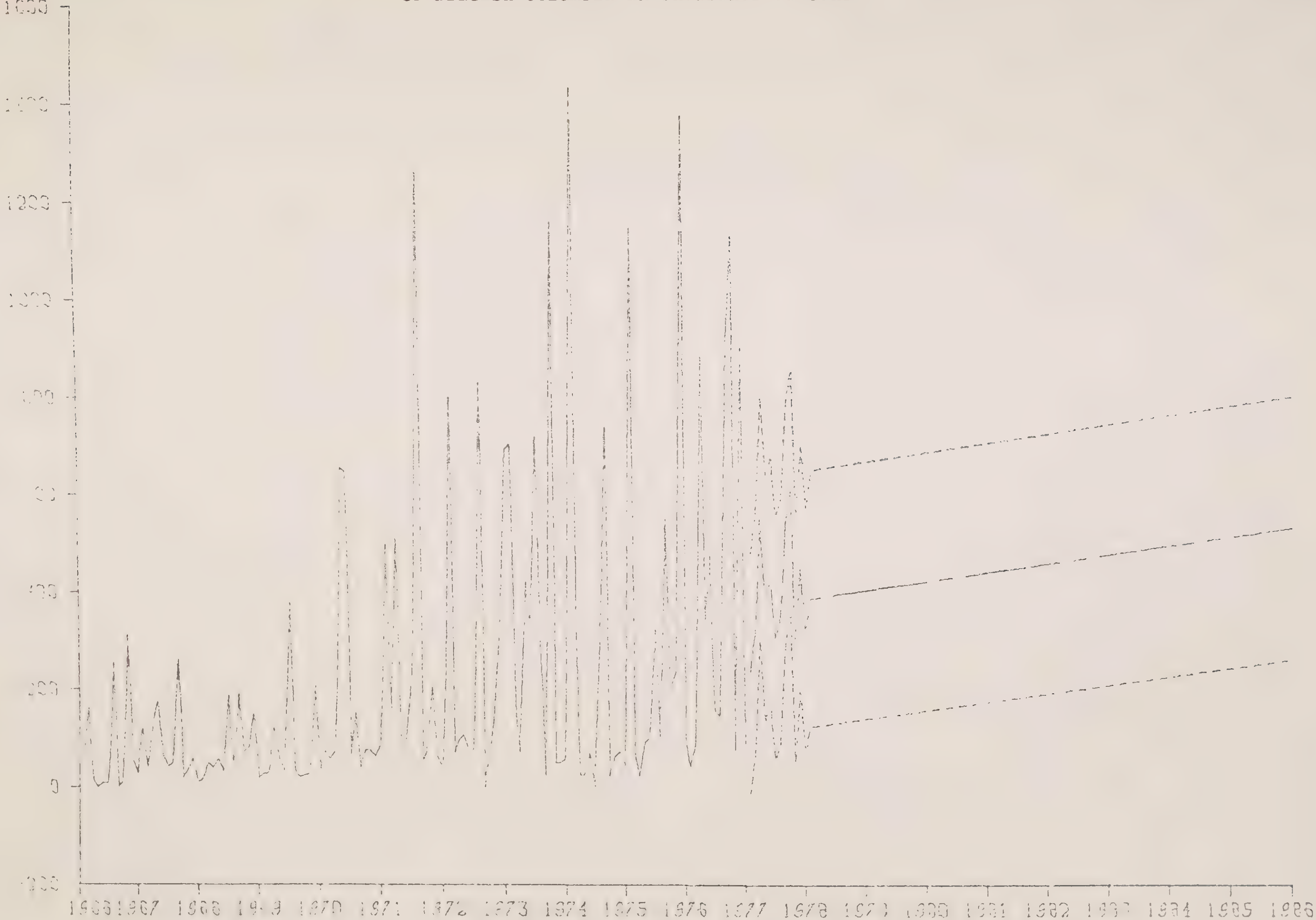
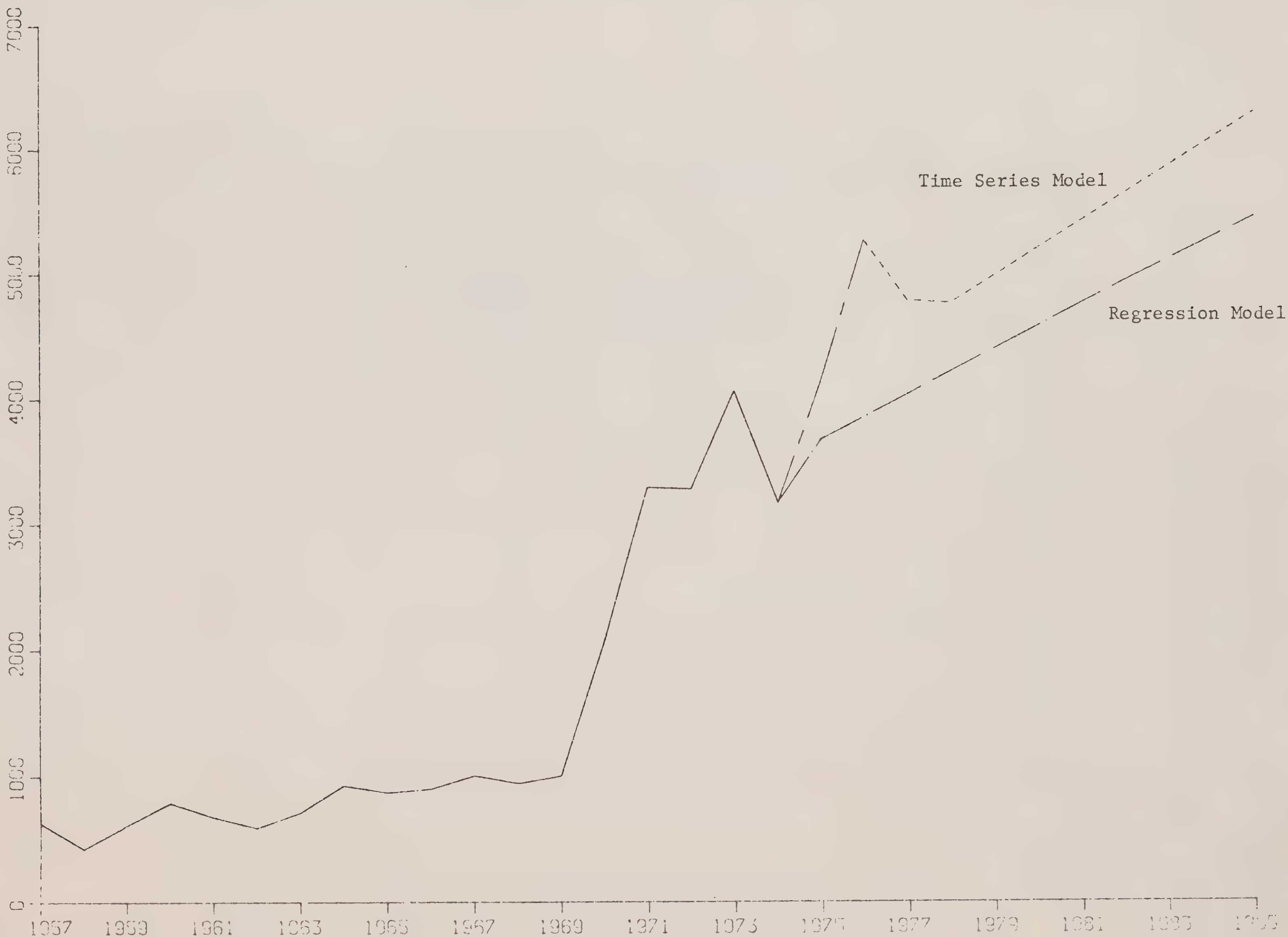


Figure 4.8: A comparison between the Regression Model and the Time Series Model for the Annual rail movement of Coal from the Prairie Provinces to British Columbia in thousands of tons



4.6 Rail Movements of Coal within British Columbia.

Data on monthly rail movements of Coal within British Columbia from January 1957 to December 1976 in thousands of tons were compiled and appear in Figure 4.9 from January 1966 onwards: unfortunately a few large movements appear to be outliers and could represent recording errors in the source documents. If Z_t represents the movement during month t in millions of tons then Z_t may be described by an integrated moving average time series model

$$W_t = (1 - \underset{(\pm 0.038)}{0.942}\, B)a_t$$

where $W_t = \nabla Z_t$ and the residual standard error is estimated to be 0.505. Diagnostic checks applied to the residuals from this model indicate significant values of the autocorrelation functions at lags 6 and 11. The model suggests that the series is homogeneous non-stationary, due to the change in the level of movements in 1970: monthly forecasts to December 1985 using this model are constant, and also appear in Figure 4.9, together with their 75% confidence limits. Owing to the pronounced non-stationarity in the data, the forecasts simply represent an overall average of the observed series to date.

These data and forecasts, on an annual basis, are given in Table 4.11 and are compared with data and forecasts from the earlier regression model in Figure 4.10. The inclusion of the exports of Coal to Japan as an explanatory variable in the regression model, and the expectation of their continued increase, led to the increase in the forecasts of Coal movements within British Columbia. Since most of this Coal is destined for export, the forecasts should be examined in the context of the overall export market that is discussed in §4.10.

Table 4.11: Annual rail movements of Coal within British Columbia in thousands of tons: the forecasts were derived from the time series model

Year	Data	Year	Forecasts
1957	11	1978	8,260
58	11	79	8,260
59	3	80	8,260
60	147	81	8,260
61	361	82	8,260
62	349	83	8,260
63	371	84	8,260
64	455	85	8,260
65	399		
66	384		
67	547		
68	499		
69	414		
70	2,588		
71	4,055		
72	6,194		
73	7,382		
74	8,442		
75	10,216		
76	7,656		

Figure 4.9: Monthly rail movements of Coal within British Columbia in thousands of tons

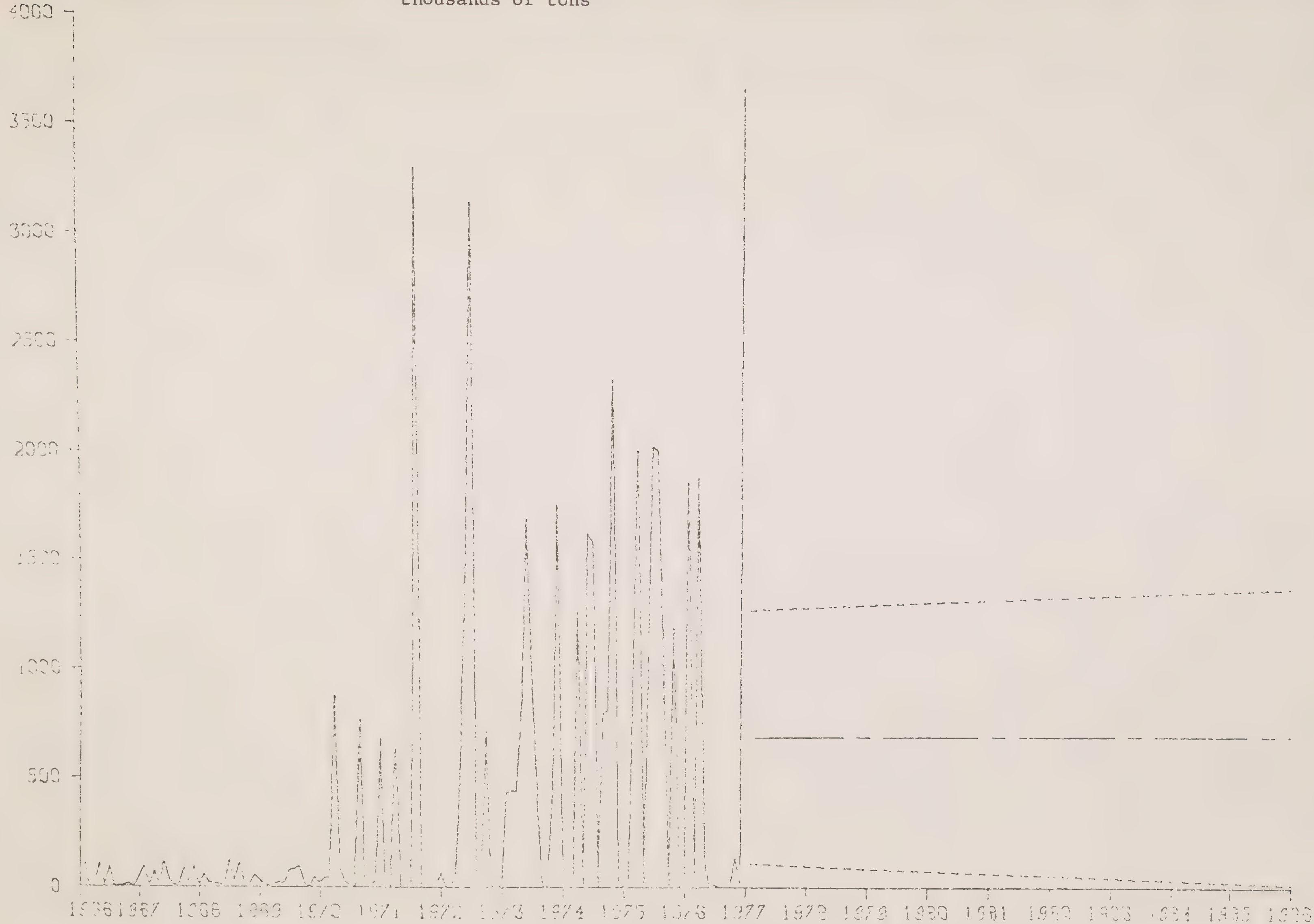
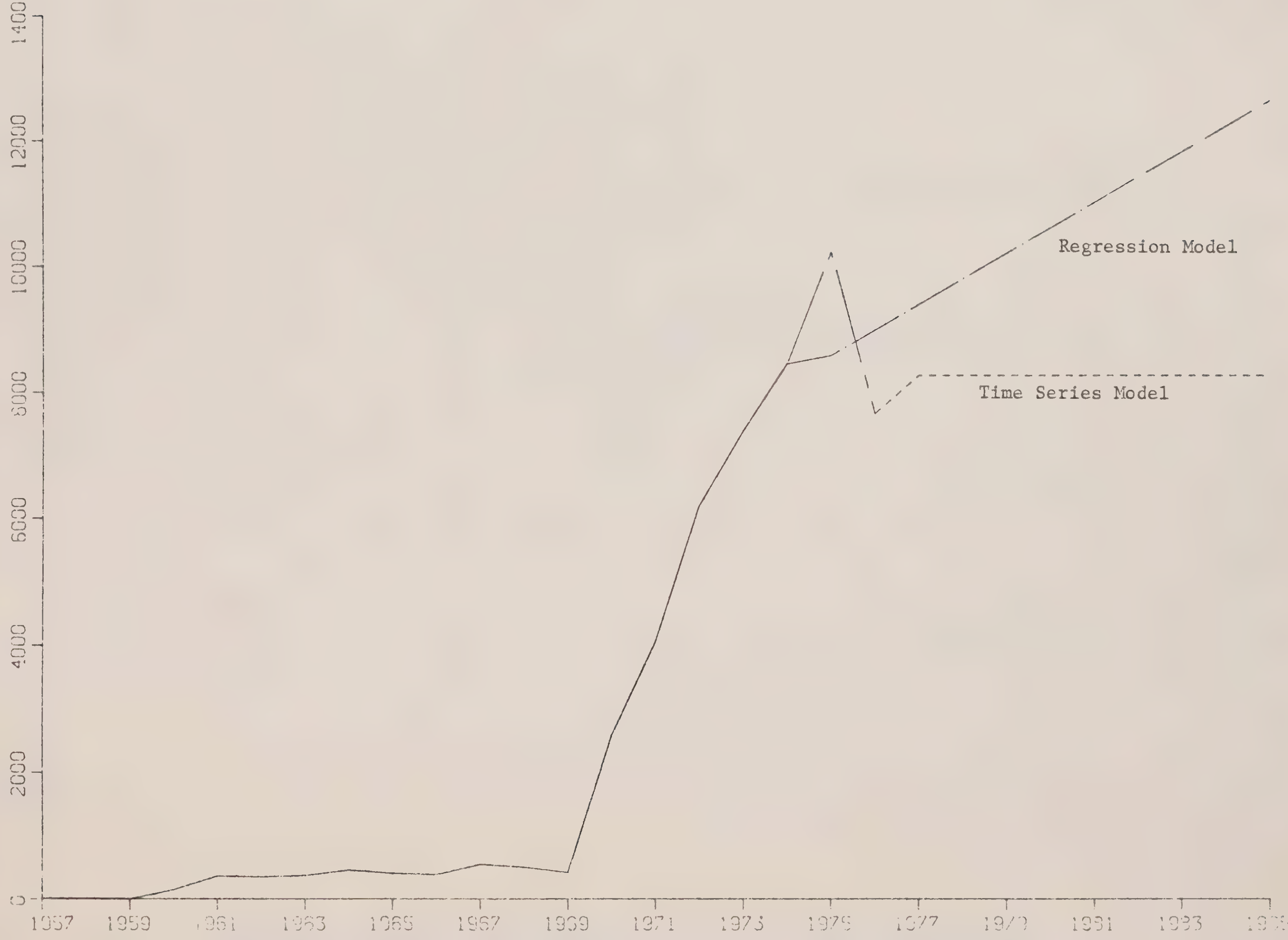


Figure 4.10: A comparison between the Regression Model and the Time Series Model for the Annual rail movements of Coal within British Columbia in thousands of tons



4.7 Rail Movements of Coal within Ontario

Data on monthly rail movements of Coal within Ontario from January 1957 to December 1976 in thousands of tons were compiled and appear in Figure 4.11 from January 1966 onwards: notice the virtual absence of movement during 1975 and 1976. If Z_t represents the movement during month t in millions of tons then Z_t may be described by a multiplicative seasonal time series model

$$\underset{(\pm 0.056)}{(1 + 0.953\, B^6)} W_t = \underset{(\pm 0.080)}{(1 - 0.778\, B)}\ \underset{(\pm 0.122)}{(1 + 0.802\, B^6)} a_t$$

where $W_t = \nabla Z_t$ and the residual standard error is estimated to be 0.0216. Diagnostic checks applied to the residuals indicate that the model is satisfactory. The model suggests that the series is homogeneous non-stationary and is seasonal with a period of 6 months rather than 12 months: monthly forecasts to December 1985 using this model, together with their 75% confidence limits, also appear in Figure 4.11. The overall decline in the series is thought to represent the decline in the use of Coal in Ontario for industrial purposes. This trend may be revised with the consideration being given to the greater use of Coal in Ontario industry: for example, Coal is increasingly being used in the production of Cement as an alternative energy source.

These data and forecasts, on an annual basis, are given in Table 4.12 and are compared with data and forecasts from the earlier regression model in Figure 4.12. Since recent rail movements within Ontario are mostly transhipments to small industrial concerns it seems reasonable that movements will be negligible as forecasted by both models.

Table 4.12: Annual rail movements of Coal within Ontario in thousands of tons: the forecasts were derived from the time series model

Year	Data	Year	Forecasts
1957	1,332	1978	70
58	1,055	79	70
59	1,032	80	70
60	952	81	70
61	790	82	70
62	610	83	70
63	532	84	70
64	745	85	70
65	695		
66	733		
67	637		
68	570		
69	450		
70	441		
71	335		
72	394		
73	311		
74	40		
75	8		
76	30		

Figure 4.11: Monthly rail movements of Coal within Ontario in thousands of tons

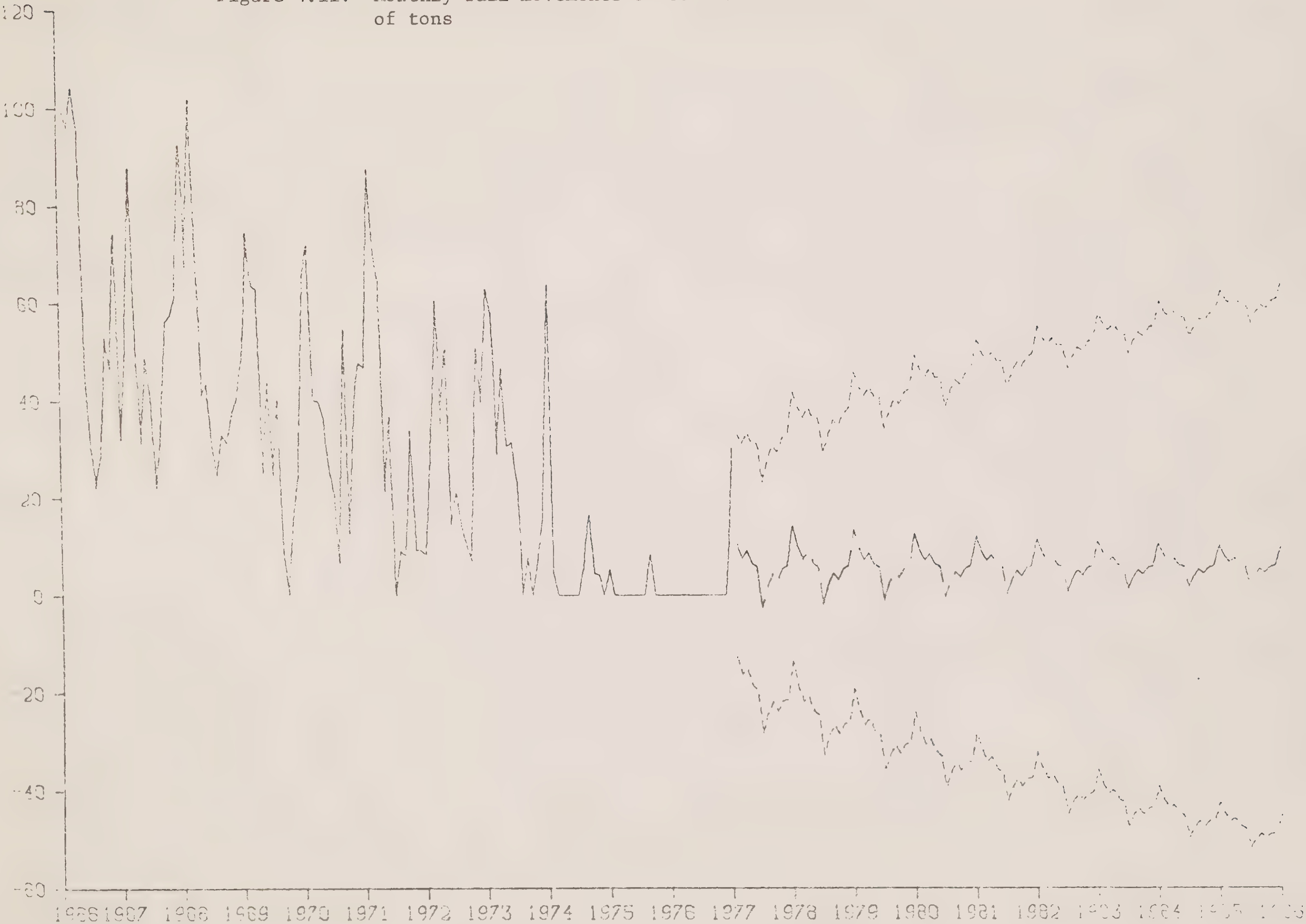


Figure 4.12: A comparison between the Regression Model and the Time Series Model for the Annual rail movements of Coal within Ontario in thousands of tons

4.8 Rail Movements of Coal from the Atlantic Provinces to Quebec.

Data on monthly rail movements of Coal from the Atlantic Provinces to Quebec from January 1966 to December 1976 in thousands of tons appear in Figure 4.13. If Z_t represents the movement during month t in millions of tons then Z_t may be described by an autoregressive time series model

$$\underset{}{(1 - \underset{(\pm 0.165)}{0.204}\,B - \underset{(\pm 0.162)}{0.315}\,B^2 - \underset{(\pm 0.162)}{0.352}\,B^3)}\tilde{Z}_t = a_t$$

$$\tilde{Z}_t = Z_t - \underset{(\pm 0.021)}{0.042}$$

and the residual standard error is estimated to be 0.0175. Diagnostic checks applied to the residuals from the model suggest the model is adequate. Monthly forecasts to December 1985 using the model, together with their 75% confidence limits also appear in Figure 4.13.

The data indicates an overall decline in shipments until 1973 when shipments began to pick up again: the forecasts suggest a very slight increase until 1985 but not back up to volumes moved in the late 1960's. Shipments from the Atlantic Provinces to Quebec are destined primarily for use by Quebec industry. Therefore an attempt was made to improve the forecasts by building a Dynamic Regression model between the monthly movements of Coal and the Index[1] of Canadian Industrial Production, recorded on a monthly basis with the base year 1961 equal to 100: a comparison of these two series appears in Figure 4.14. The two series do not appear to be strongly related which in part must be due to the fact that the Index of Industrial Production is for Canada as a whole, since no such Index for Quebec is available and

[1] Statistics Canada 61-005: Indexes of Real Domestic Product by Industry.

because the index is a general industrial index and does not adequately reflect the changing market conditions of those industrial concerns using Coal in Quebec, in particular the Pulp and Paper Industry and the Iron and Steel Foundries. The process of developing a Dynamic Regression model fails to indicate any significant Transfer Function between the two series.

An alternative explanation for the trends in the Coal movement is that the shift away from Coal to alternative fuels such as Petroleum was in part a result of the relative prices of Petroleum and Coal, and the increase in shipments of Coal after 1973 was in response to the higher prices for Petroleum following the so called 'Oil Crisis'. To examine this hypothesis a relative price index between Petroleum and Coal was calculated as a quotient of the Producer Price Index of Petroleum[2] and a Coal Price Index, comprising of the Wholesale Price of Coal[3] in current Canadian dollars from January 1966 to December 1971, adjusted by a GNP deflator[4], together with the Purchase Price Index of Thermal Coal[5] from January 1972 to December 1976. The calculation of this relative price index, using data from different sources and for different time periods, was necessitated by the absence of any readily available published statistics: a comparison of the monthly movements of Coal and this relative price index appears in Figure 4.15. Again the two series do not seem to be strongly related which in part must be due to the fact that the relative price index does not reflect regional price differences or price differences due to the qualities of Coal involved; and that the rapid increase

[2] O.E.C.D. (1960-75). Main Economic Indicators: Historical Statistics

[3] U.N. Monthly Bulletin of Statistics

[4] Bank of Canada Review

[5] Statistics Canada 62-011. Industry Price Indices

in the price of Petroleum after the Oil Crisis was followed by a corresponding increase in Coal prices so that the relative price index returned to former levels. Perhaps not surprisingly the process of developing a Dynamic Regression model fails to indicate any significant Transfer Function between the two series.

Lastly the effect of Rail Freight Rates for Coal[6] between the Atlantic Provinces and Quebec on the monthly rail movement of Coal was examined: the Rail Freight Rates, adjusted by a GNP deflator, appeared in Figure 4.16. The two series do not appear to be strongly related and the process of developing a Dynamic Regression Model fails to indicate any significant Transfer Function between the two series.

Data and forecasts, on an annual basis, derived from the autoregressive time series model are given in Table 4.13 and are compared with data and forecasts from the earlier Regression Model in Figure 4.17. The regression model forecasts a decline in the next few years due to low production but rises again after 1981 owing to expected increased demand.

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[6] Compiled from Computer Tapes which are summarised in 'Waybill Analysis: Carload All-Rail Traffic, Canadian Transport Commission

Table 4.13: Annual rail movements of Coal from the Atlantic Provinces to Quebec in thousands of tons: the forecasts were derived from the time series model

Year	Data	Year	Forecasts
1966	784	1978	490
67	797	79	500
68	755	80	500
69	809	81	500
70	449	82	500
71	422	83	500
72	79	84	500
73	97	85	500
74	248		
75	350		
76	327		

Figure 4.13: Monthly rail movements of Coal from the Atlantic Provinces to Quebec in thousands of tons

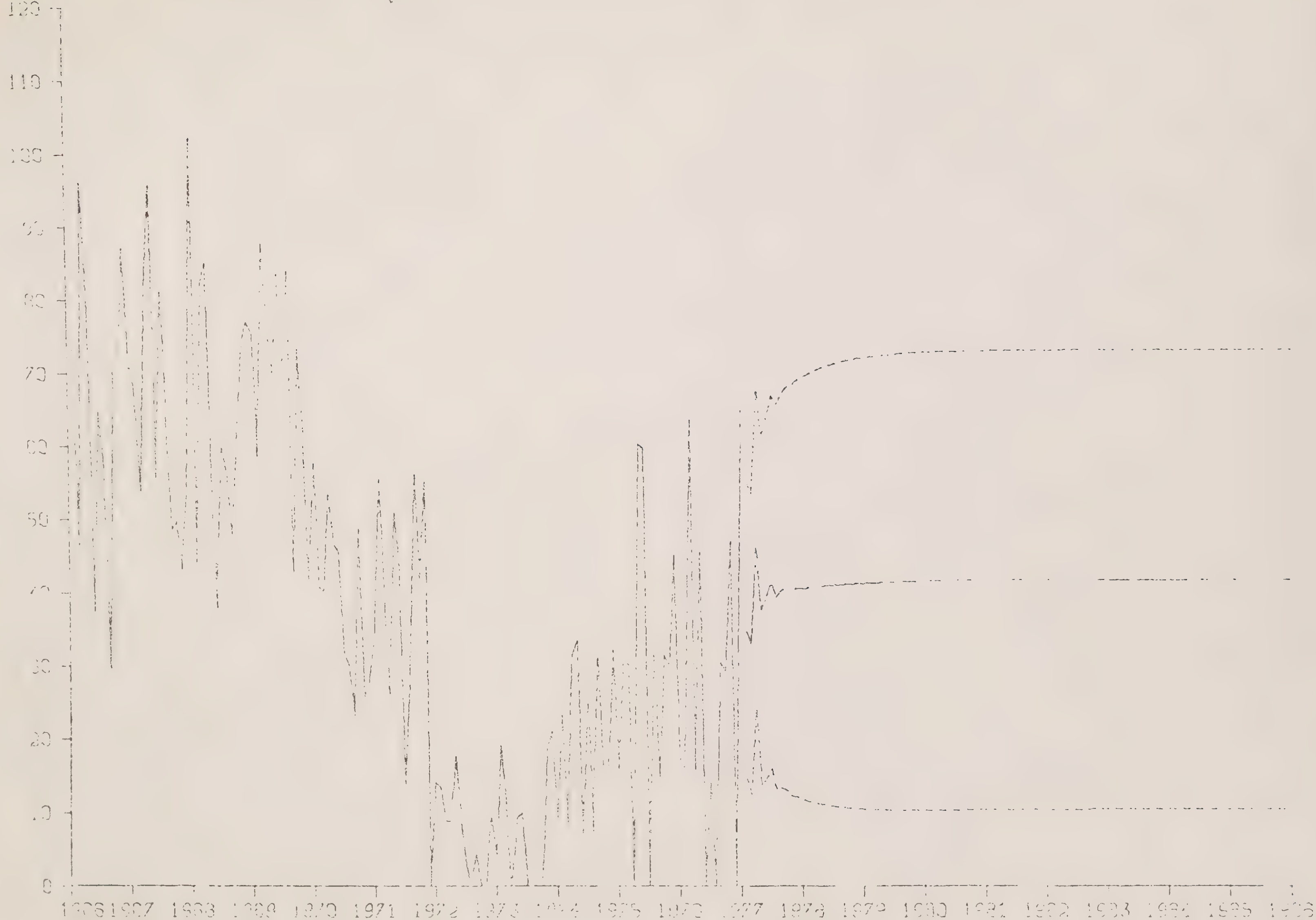
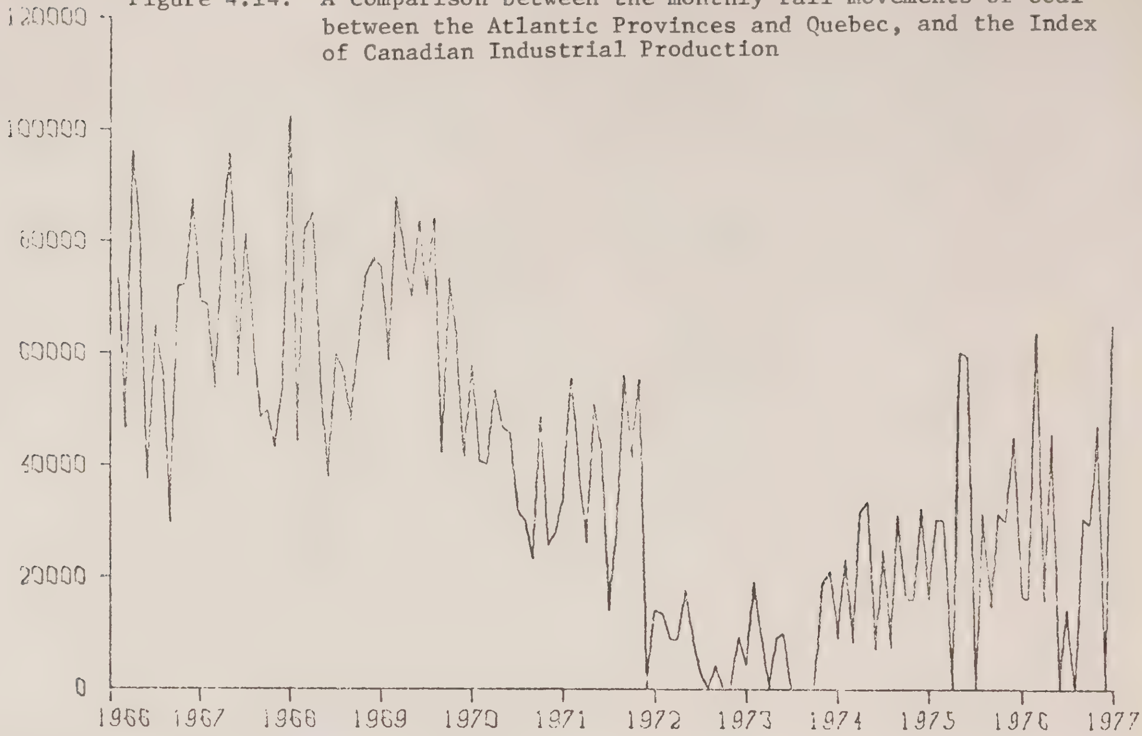
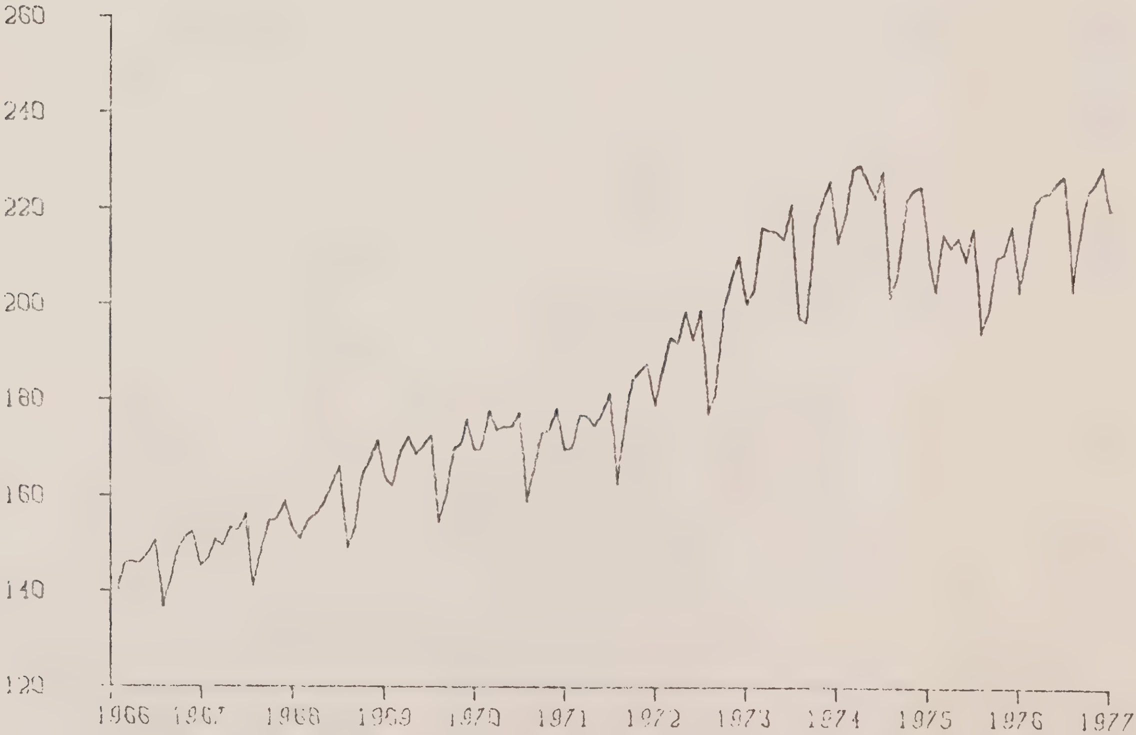


Figure 4.14: A comparison between the monthly rail movements of Coal between the Atlantic Provinces and Quebec, and the Index of Canadian Industrial Production

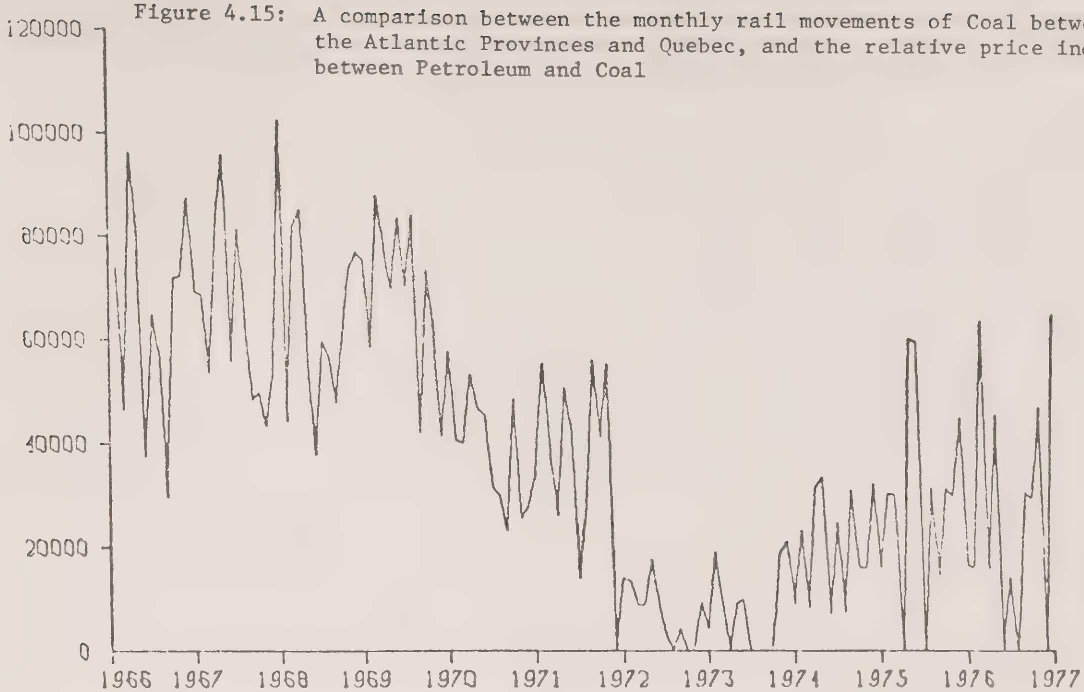


Monthly rail movements of Coal between the Atlantic Provinces and Quebec in tons

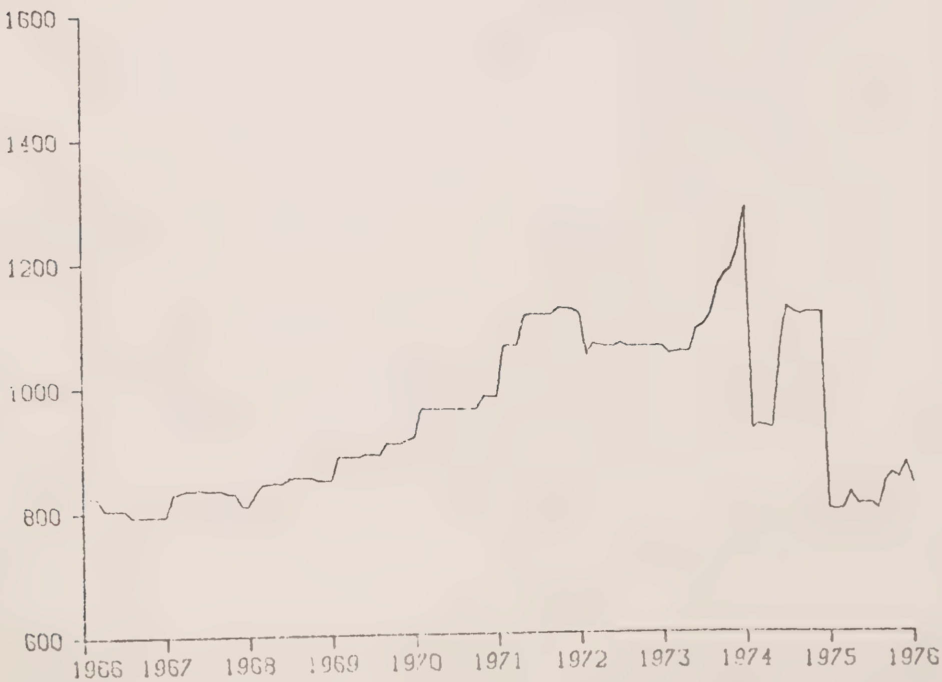


Index of Canadian Industrial Production with base year 1961 = 100

Figure 4.15: A comparison between the monthly rail movements of Coal between the Atlantic Provinces and Quebec, and the relative price index between Petroleum and Coal

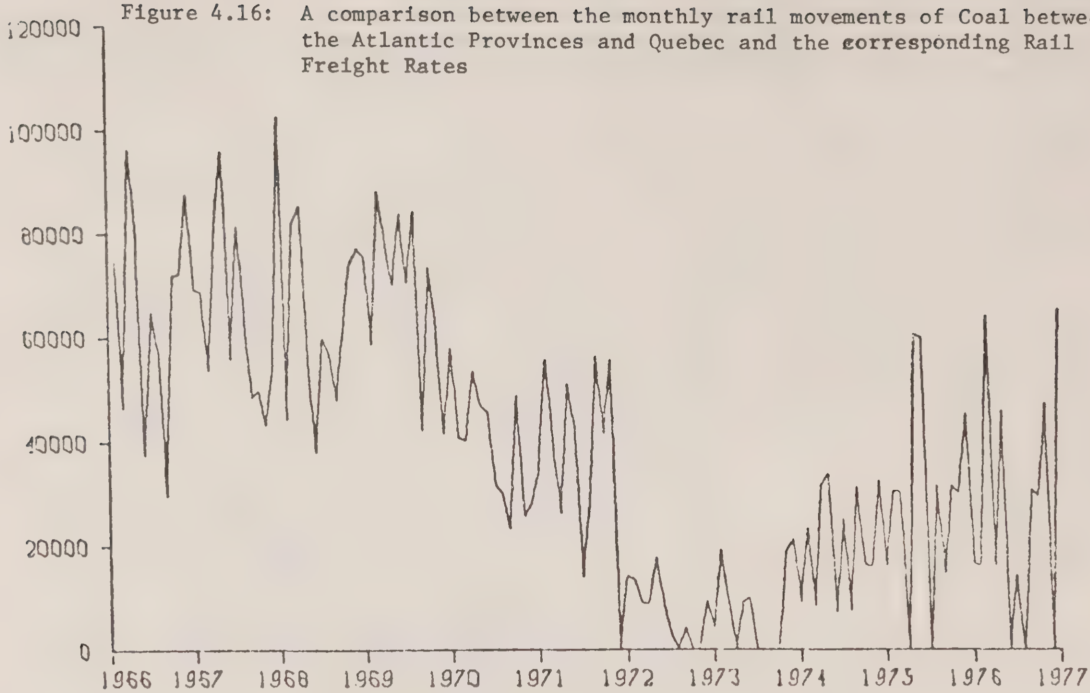


Monthly rail movements of Coal between the Atlantic Provinces and Quebec in tons

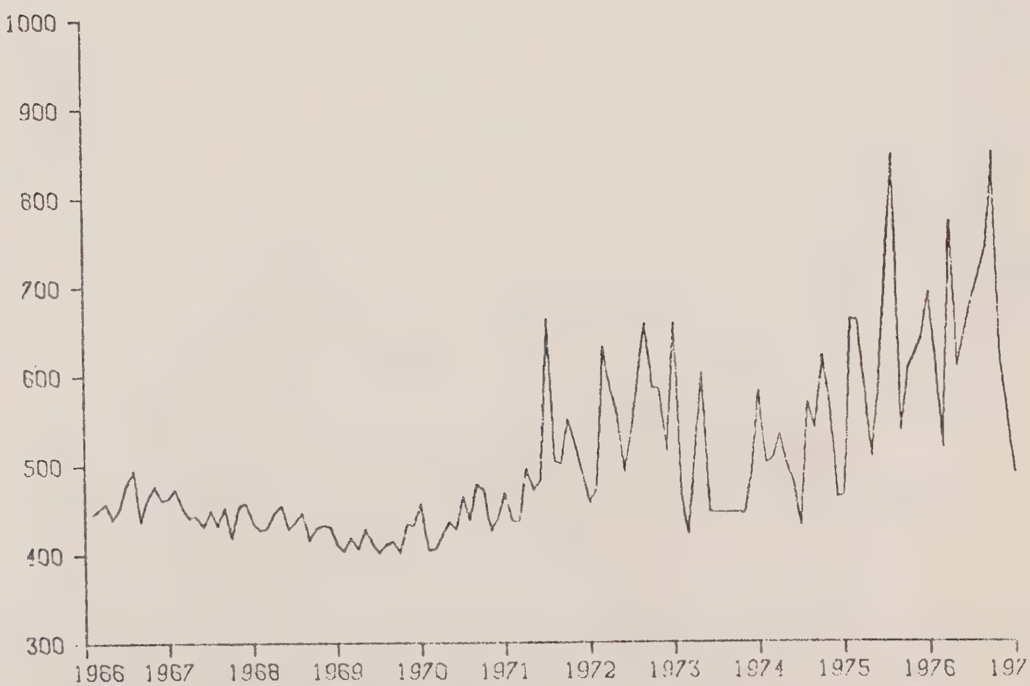


Relative Price Index between Petroleum and Coal scaled by a factor of 1000

Figure 4.16: A comparison between the monthly rail movements of Coal between the Atlantic Provinces and Quebec and the corresponding Rail Freight Rates

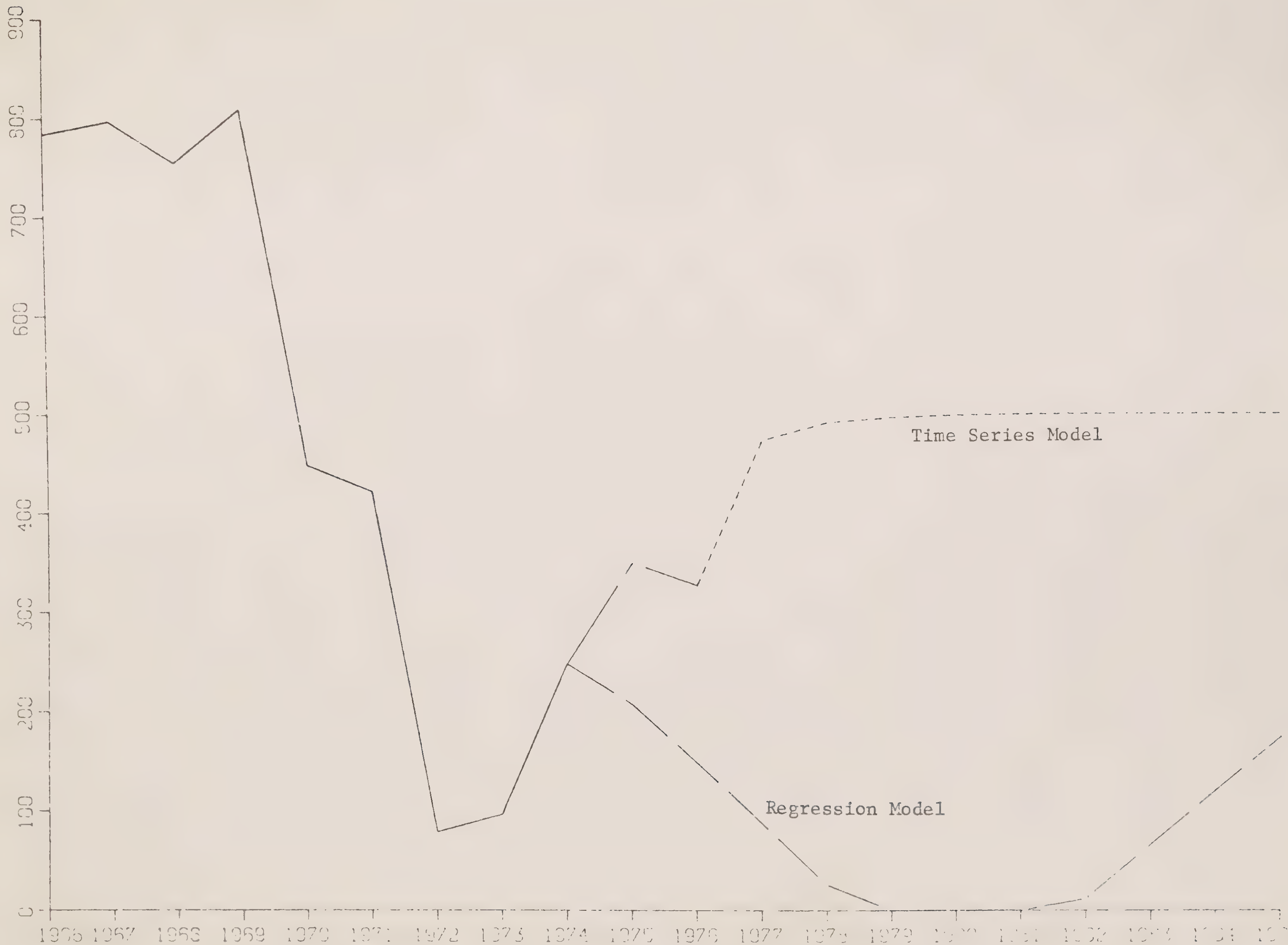


Monthly rail movements of Coal between the Atlantic Provinces and Quebec in tons



Monthly Rail Freight Rates for Coal shipped between the Atlantic Provinces and Quebec

Figure 4.17: A comparison between the Regression Model and the Time Series Model for the Annual rail movement of Coal from the Atlantic Provinces to Quebec in thousands of tons



4.9 Imports of Coal from the United States to Ontario

Data on monthly imports of Coal from the United States to Ontario from January 1966 to December 1975 in thousands of tons appear in Figure 4.18. Two modes of transport are used with approximately 95% of shipments by marine mode and 5% by rail. A Coal strike in the United States in 1974 resulted in the observed reduction in imports during that year with the corresponding increased use of Ontario stockpiles of Coal for that year is indicated in Table 4.2. If Z_t represents the movement during month t in millions of tons then Z_t may be described by a multiplicative seasonal time series model

$$W_t = (1 + \underset{(\pm 0.179)}{0.355}\, B)\ (1 - \underset{(\pm 0.059)}{0.875}\, B^{12})a_t$$

where $W_t = \nabla_{12} Z_t$ and the residual standard error is estimated to be 0.369. Diagnostic checks indicate that the model is adequate. The model indicates that the series has a pronounced seasonal pattern which reflects the closure of the Great Lakes System during the winter months: monthly forecasts to December 1985 using this model also appear in Figure 4.18 together with their 75% confidence limits. The forecasts indicate a continuation of the pronounced seasonal pattern but with no upward or downward sloping trend.

Coal is in demand in Ontario for electrical generation by Ontario Hydro and as was indicated earlier most of Ontario's Coal is currently imported from the United States. Therefore an attempt was made to improve the forecasts by building a Dynamic Regression model between the monthly imports of Coal and the monthly quantities of Conventional Thermal Electricity generated in Ontario[1]: a comparison of these two series appears

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[1]Statistics Canada 57-001: Electric Power Statistics

in Figure 4.19. The two series both exhibit seasonal patterns but while Electrical Generation has followed an upward trend Coal shipments have remained steady. The process of developing a Dynamic Regression model fails to indicate any significant Transfer Function between the two series.

The second largest demand for Coal in Ontario is for coke making. As a result an attempt was made to improve the forecasts by building a Dynamic Regression model between the monthly imports of Coal and the Total Monthly Steel Production for Canada[2]: a comparison of these two series appears in Figure 4.20. Notice the large drop in production in August, September and October 1969 due to strikes at the Algoma Steel Corporation and the Steel Company of Canada, and the overall upward trend in production. The process of developing a Dynamic Regression model fails to indicate any significant Transfer Function between the two series perhaps because the Steel Production figures are for Canada as a whole, rather than for Ontario whose Steel Production figures are not readily available.

Data and forecasts, on an annual basis, derived from the multiplicative seasonal time series model are given in Table 4.14 and are compared with data and forecasts from the earlier Regression Model in Figure 4.21. The Regression Model forecasts an increase in Coal movements while the time series model forecasts approximately constant movements. The inclusion of Conventional Thermal Electricity generation in Ontario as an explanatory variable in the regression model, and the expectation of its continued increase, led to the sharp increases in the forecasts of Coal movements. Opinion seems to suggest that the movements of Coal will remain steady in the

[2] Statistics Canada 41-001: Primary Iron and Steel

short run, particularly for the duration of the current slump in the world-wide market for Steel, but may pick up in the longer run in response to increased use of Coal in the industrial sector. The intention of Ontario Hydro to use increasing quantities of Coal from the Prairie Provinces and British Columbia may not have the expected effect of a reduction in imports from the United States. Environmental protection standards in the United States preclude the use of Coal with a high sulphur content so that the price of this type of Coal has fallen. However this Coal may be blended with the Western Canadian Coal of low sulphur content for use by Ontario Hydro so that continued imports of United States Coal at current levels are expected.

Table 4.14: Annual imports of Coal from the United States to Ontario in thousands of tons: the forecasts were derived from the time series model

Year	Data	Year	Forecasts
1966	15,025	1978	15,840
67	14,840	79	15,840
68	15,659	80	15,840
69	15,939	81	15,840
70	17,687	82	15,840
71	17,180	83	15,840
72	18,420	84	15,840
73	15,475	85	15,840
74	12,849		
75	15,929		

Figure 4.18: Monthly imports of Coal from the United States to Ontario in thousands of tons

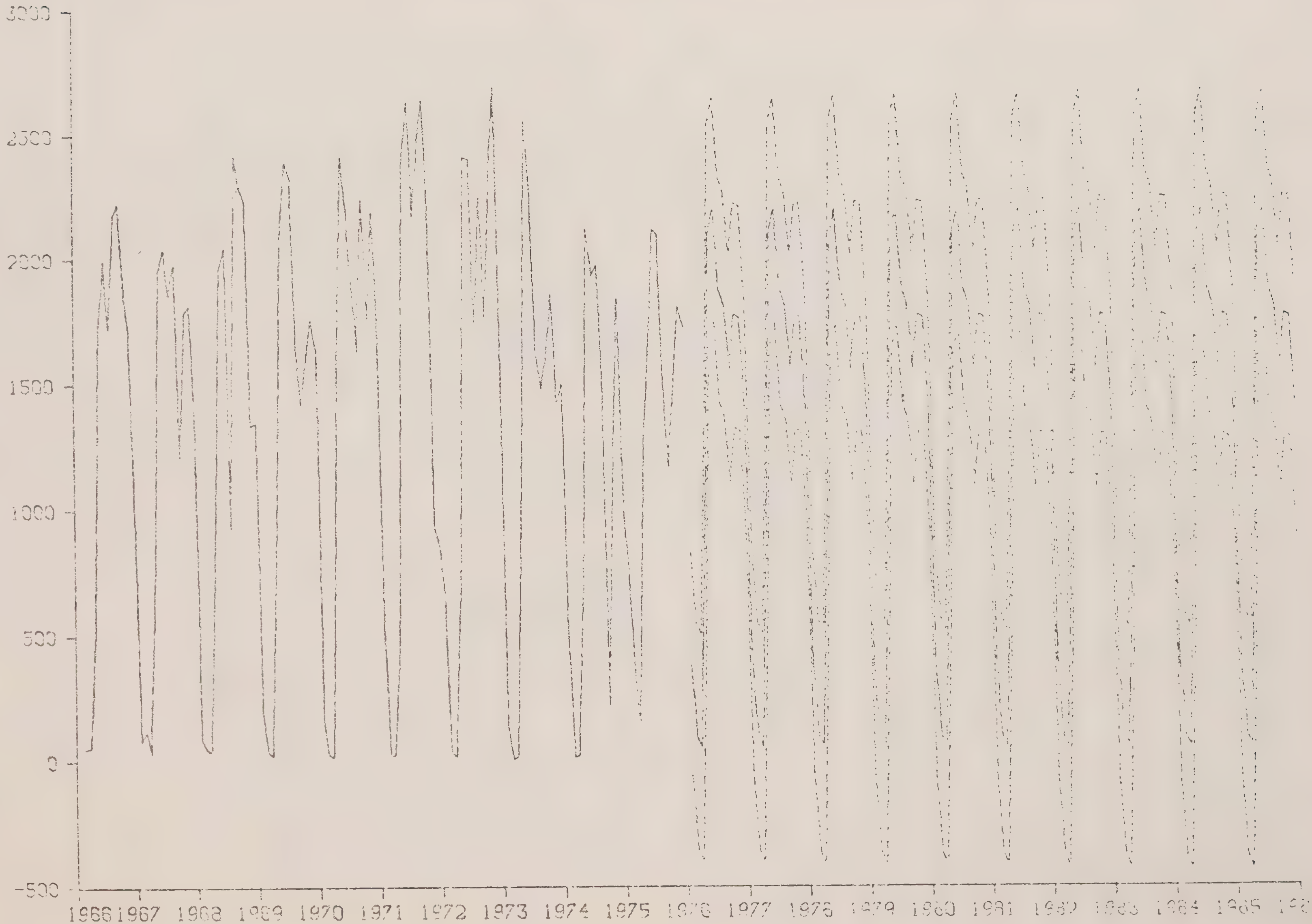
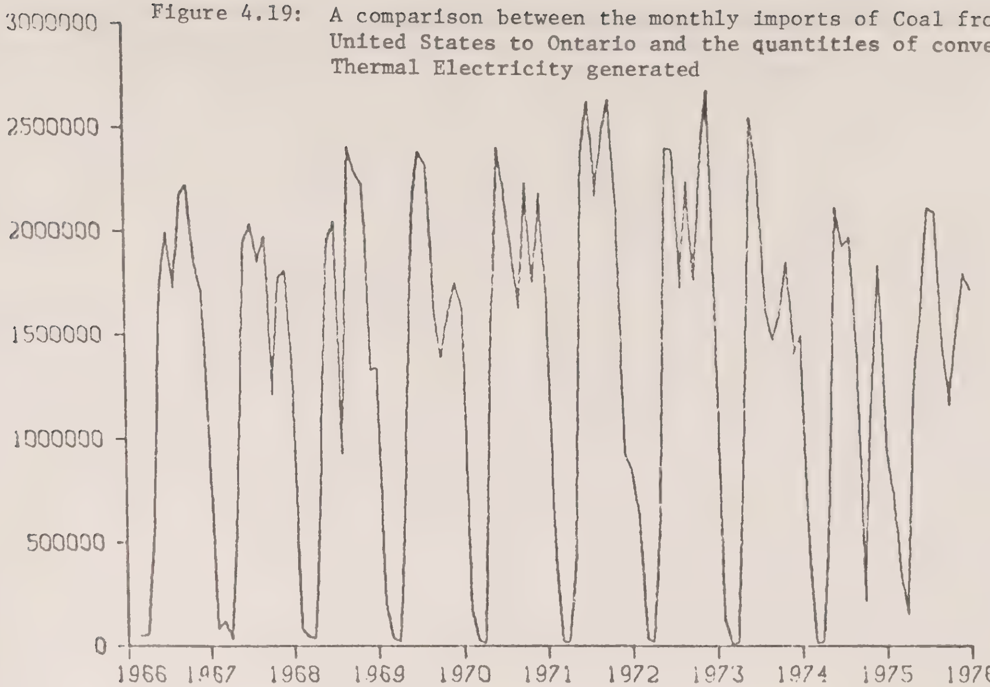
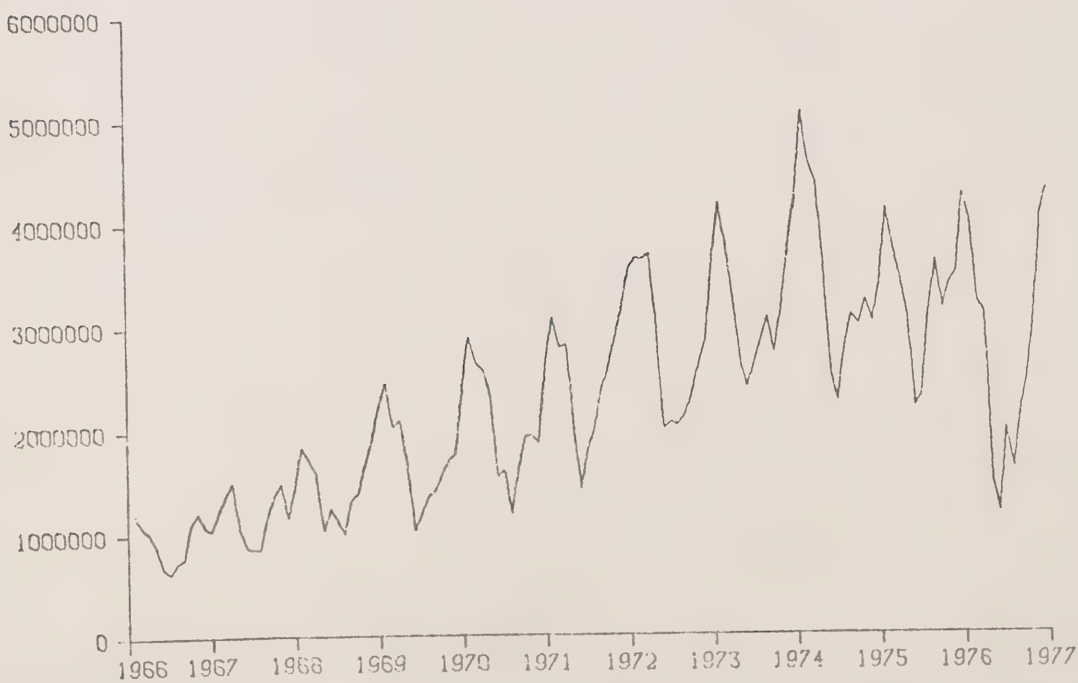


Figure 4.19: A comparison between the monthly imports of Coal from the United States to Ontario and the quantities of conventional Thermal Electricity generated

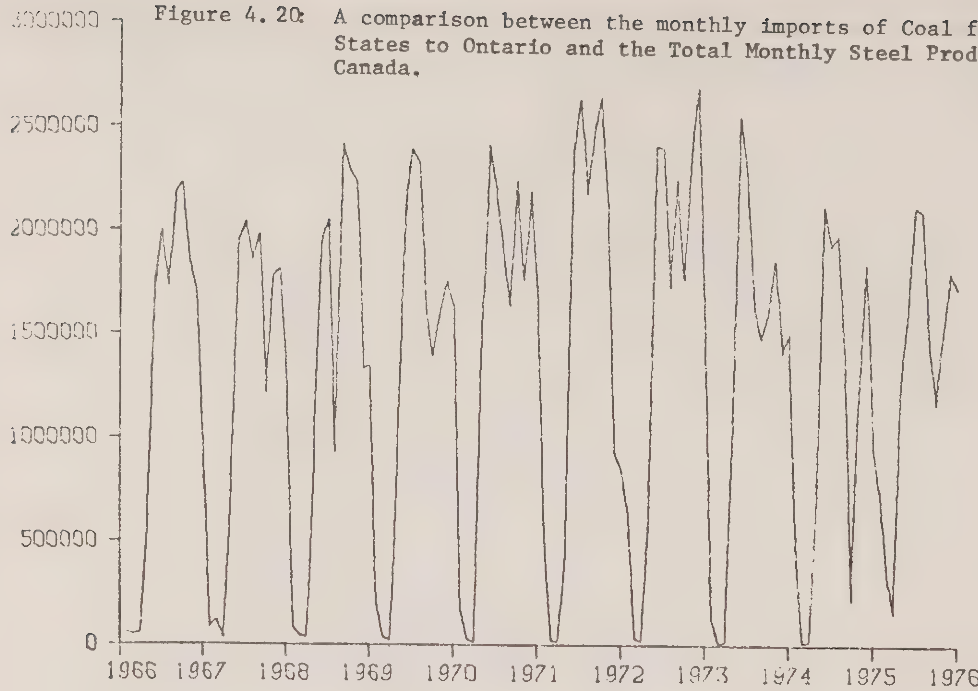


Monthly imports of Coal from the United States to Ontario in tons

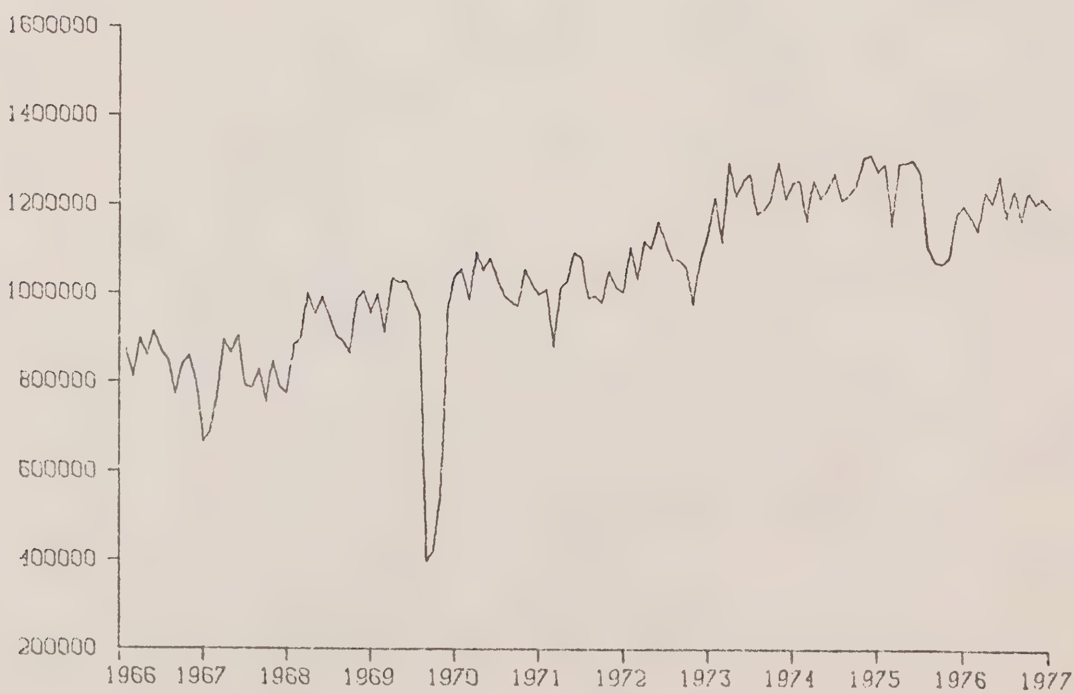


Monthly quantities of conventional Thermal Electricity generated in thousands of Kilowatt-Hours

Figure 4.20: A comparison between the monthly imports of Coal from the United States to Ontario and the Total Monthly Steel Production for Canada.

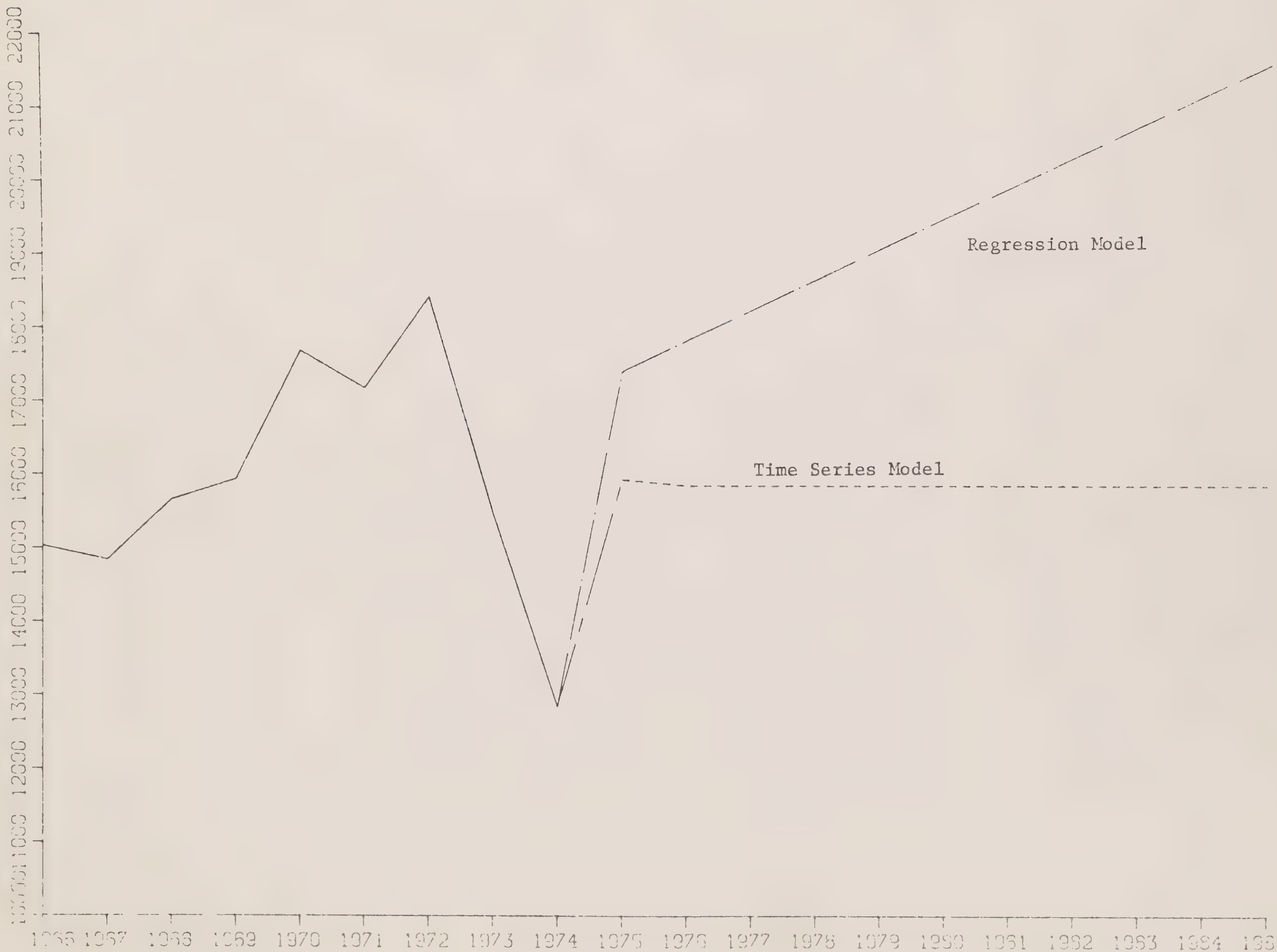


Monthly imports of Coal from the United States to Ontario in tons



Total Monthly Steel Production for Canada in tons.

Figure 4.21: A comparison between the Regression Model and the Time Series Model for the Annual imports of Coal from the United States to Ontario in thousands of tons



4.10 Marine Exports of Coal from British Columbia to Japan

Data on monthly marine exports of Coal from British Columbia to Japan from January 1966 to December 1976 in thousands of tons appear in Figure 4.22. If Z_t represents the movement during month t in millions of tons then Z_t may be described by a moving average time series model

$$W_t = (1 - \underset{(\pm 0.0995)}{0.802}\, B)a_t$$

where $W_t = \nabla Z_t$ and the residual standard error is estimated to be 0.227. Diagnostic checks applied to the residuals indicate that the model is adequate.

The model suggests that the series is homogeneous non-stationary by virtue of the large increase in monthly movements that took place, beginning in 1970: monthly forecasts to December 1985 using this model also appear in Figure 4.22 together with their 75% confidence limits.

The Coal being shipped from British Columbia to Japan is produced in Coal mines in British Columbia and Alberta. Therefore an attempt was made to improve the forecasts by building a Dynamic Regression model between the monthly exports of Coal and the Production of Coal of all types[1] from British Columbia and the Prairies: a comparison of the two series appear in Figure 4.23. If X_t represents the Coal production during month t in millions of tons then X_t may be described by a multiplicative moving average time series model:

$$\nabla X_t = (1 - \underset{(\pm 0.168)}{0.222}\, B)\ (1 + \underset{(\pm 0.207)}{0.356}\, B^{12})a_t$$

The model suggests that the series is homogeneous non-stationary as is apparent from examination of the observed data: monthly forecasts of Coal production to December 1985 using this model

[1]Statistics Canada 45-002: Coal and Coke Statistics

also appear in Figure 4.23. The process of developing a dynamic regression model indicates that the relationship between X_t and Z_t may be described by the model

$$\nabla Z_t = \underset{(\pm 0.136)}{0.305}\ \nabla X_{t-2} + N_t$$

where the residual standard error is now estimated to be 0.212 and the noise N_t may be described by a moving average model

$$\tilde{N}_t = N_t - \underset{(\pm 0.0039)}{0.00397} = (1 - \underset{(\pm 0.070)}{0.916}\ B)a_t$$

The dynamic regression model suggests that the monthly differences in movement of Coal from British Columbia to Japan are approximately 30% of the monthly differences in Coal production in British Columbia and the Prairies two months earlier. This lag of two months represents an average time between the extraction of the Coal at the mine and the loading of the Coal on board ship ready for transit to Japan. Monthly forecasts of Coal movements to December 1985 using this model appear in Figure 4.23 and the corresponding 75% confidence limits are slightly narrower than those appearing in Figure 4.22 indicating a marginal improvement in modelling.

The Supply and Demand analysis in §4.1 suggested that the type of Coal shipped to Japan was primarily Bituminous Coal. Therefore further improvement in the forecast was sought by building a Dynamic Regression model between the monthly export of Coal and the Production of Bituminous Coal[2] for British Columbia and the Prairies: a comparison between the two series appears in Figure 4.24. If X_t now represents the Bituminous Coal production during month t in millions of tons then X_t may be described by a multiplicative moving average time series model

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[2]Statistics Canada 45-002: Coal and Coke Statistics

$$\nabla X_t = \underset{(\pm 0.171)}{(1 - 0.189\, B)}\ (1 - \underset{(\pm 0.174)}{0.269\, B^3} + \underset{(\pm 0.176)}{0.191\, B^6})a_t$$

The model indicates that the series is homogeneous non-stationary with a three month seasonaly component: monthly forecasts of Bituminous Coal production to December 1985 using this model also appear in Figure 4.24. The process of developing a Dynamic Regression model indicates that the relationship between X_t and Z_t may be described by the model

$$\nabla Z_t = \underset{(\pm 0.161)}{0.600}\ \nabla X_{t-2} + N_t$$

where the residual standard error is now estimated to be 0.209 and the noise N_t may be described by a moving average model

$$\tilde{N}_t = N_t - \underset{(\pm 0.0024)}{0.00249} = (1 - \underset{(\pm 0.038)}{0.994}\, B)a_t$$

This dynamic regression model suggests that the monthly differences in movement of Coal from British Columbia to Japan are approximately 60% of the monthly differences in Bituminous Coal production in British Columbia and the Prairies two months earlier. Monthly forecasts of Coal movements to December 1985 using this model appear in Figure 4.24 and the corresponding 75% confidence limits being slightly narrower than those in Figure 4.23 suggest a further improvement in modelling.

Consideration was now given to improving the model by the introduction of an indicator of demand for Coal in Japan. Since the Coal is used to make Coke and thereby to produce Steel an attempt was made to improve the forecasts by building a Dynamic Regression model between the monthly exports of Coal and the Total Crude Steel Production in Japan: a comparison of the two series appears in Figure 4.25. While both series exhibit

[3] Monthly Reports of the Iron and Steel Statistics. The Japan Iron and Steel Federation.

upward trends, the relationship between them appears weak and the process of developing a dynamic regression model fails to indicate any significant Transfer Function between the two series: this must be due in part to the policy of the Japanese Steel Consumption of diversifying its sources of supply. Note, however, that while the relationship between the two series, as indicated by the Transfer Function, is not significant, a lag of three months between Steel Production and Coal movement is suggested. The fact that this is a lag and not a lead may be somewhat surprising and might be a result of the long-term Contracts for Coal shipments that exist between Canada and Japan which would tend to leave shipments unaffected by temporary shifts in the Japanese Steel market.

Since these Contracts for Coal supplies are close to what may be described as policy instruments, an attempt was made to build a dynamic regression model between the monthly export of Coal and the signed Coal Contracts between Coal producers in British Columbia and the Prairies and the Japanese Steel Consortium[4]: a comparison of the two series appear in Figure 4.26. If X_t now represents the average monthly quantity of Coal contracted to be supplied during month t, then the process of developing a dynamic regression model indicates that the relationship between X_t and Z_t may be described by the model

$$\nabla Z_t = \underset{(\pm 0.159)}{0.631}\,\nabla X_{t-3} + N_t$$

where the residual standard error is now estimated to be 0.216 and the noise N_t may be described by a moving average model

$$N_t = (1 - \underset{(\pm 0.056)}{0.940}\,B)a_t$$

The dynamic regression model suggests that the monthly differences

[4] Specified by E. Weinberg, Director, Freight Studies Directorate, Research Branch, Canadian Transport Commission

in movement of Coal from British Columbia to Japan are approximately 63% of the average monthly differences in the quantity of Coal contracted to be supplied three months earlier. This might suggest that there is a three months delay by Coal producers in bringing onstream increases or decreases in contracted Coal supplies. Monthly forecasts of Coal movements to December 1985 using this model appears in Figure 4.26: note that the expected Coal Contracts used to provide the forecasts of movements were not estimated from a time series model, as in the earlier dynamic regression models, but were specified from Industry sources. The 75% confidence limits are narrower then those in any of the earlier models suggesting a further improvement in modelling.

Lastly the additional effect of Rail Freight Rates for Coal[5] between the Prairie Provinces and British Columbia on the monthly export of Coal was examined: the Rail Freight Rates, adjusted by a GNP deflator, appear in Figure 4.27. The two series do not appear related and the process of developing a dynamic regression model fails to indicate any significant Transfer Function between the two series: this must be due in part to the fact that a substantial portion of the Coal shipped from British Columbia to Japan is mined in British Columbia itself so that the Rail Freight Rates used here may not represent the complete picture.

A comparison between the monthly forecasts from the time series model and the dynamic regression models appears in Figure 4.28 while data and forecasts on an annual basis, from the time series model, the dynamic regression model and the earlier regression model appear in Figure 4.29. In Table 4.15 we present the numerical data and annual forecasts obtained from the dynamic regression models using the various leading

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[5]Compiled from Computer Tapes which are summarised in 'Waybill Analysis: Carload All-Rail Traffic', Canadian Transport Commission

indicators. Events suggest that, owing to a slump in the Japanese Steel Industry, in the short run the drop in exports of Coal as forecast by the dynamic regression model using the signed Coal Contracts as leading indicator is most realistic. In fact most recent reports[6] indicate that even these forecasts may be optimistic: referring to the latest contract between a group of eight major Japanese steelmakers and McIntyre-Porcupine Mines Ltd. 'the actual tonnage shipped by McIntyre during the next year could be down 47 per cent from the volume delivered in 1977' and 'one must keep in mind that the Japanese took 1.2 million tons in 1977, 12 per cent less than contracted for'. In the longer run the volumes of shipments may be expected to rise again when the Japanese steel industry picks up: in addition there have been suggestions that Bituminous Coal may be exported to Japan for purposes of Electricity generation. Overall exports from British Columbia may also be expected to rise as efforts to diversify the export market, to include such countries as South Korea, Denmark, Germany, France, Brazil and Mexico, intensify. Opinion seems agreed that the current reduction in exports of Coal will be followed by a period of growth but opinions differ on just how long the slump will last.

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[6] C.P. News Summary, April 14th 1978

Table 4.15: Annual exports of Coal from British Columbia to Japan in thousands of tons: the forecasts were derived from the dynamic regression models using the different leading indicators

Year	Data	Year	Forecasts using as Leading Indicators: Total Coal Production	Bituminous Coal Production	Signed Coal Contracts
1966	1,060	1978	15,890	14,130	11,540
67	1,167	79	16,460	14,490	10,210
68	1,273	80	17,030	14,850	9,760
69	1,056	81	17,600	15,210	9,760
70	4,123	82	18,170	15,570	9,760
71	7,408	83	18,740	15,930	9,760
72	8,296	84	19,310	16,280	9,760
73	11,712	85	19,890	16,640	9,760
74	10,993				
75	11,866				
76	11,685				

Figure 4.22: Monthly marine exports of Coal from British Columbia to Japan in thousands of tons

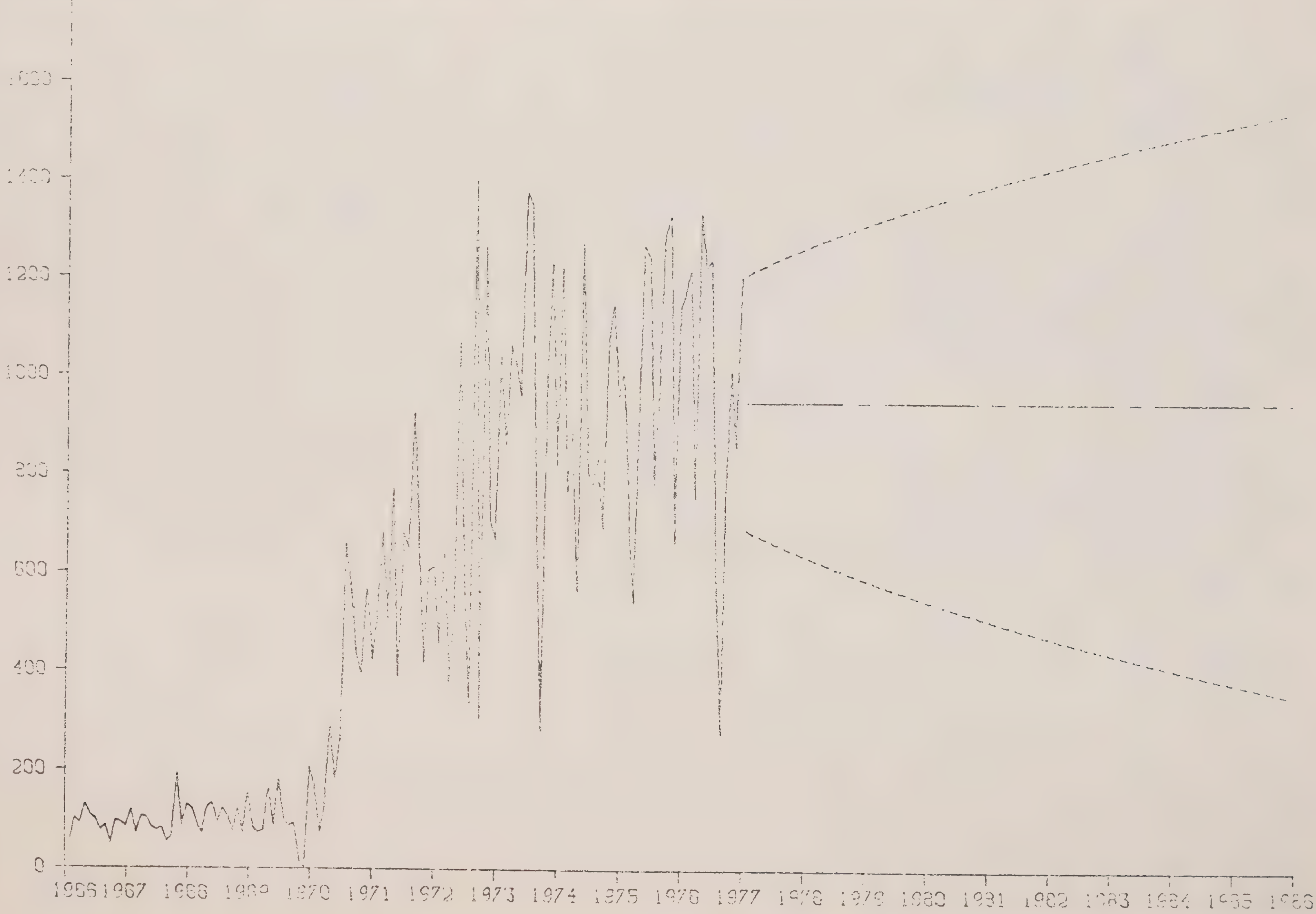
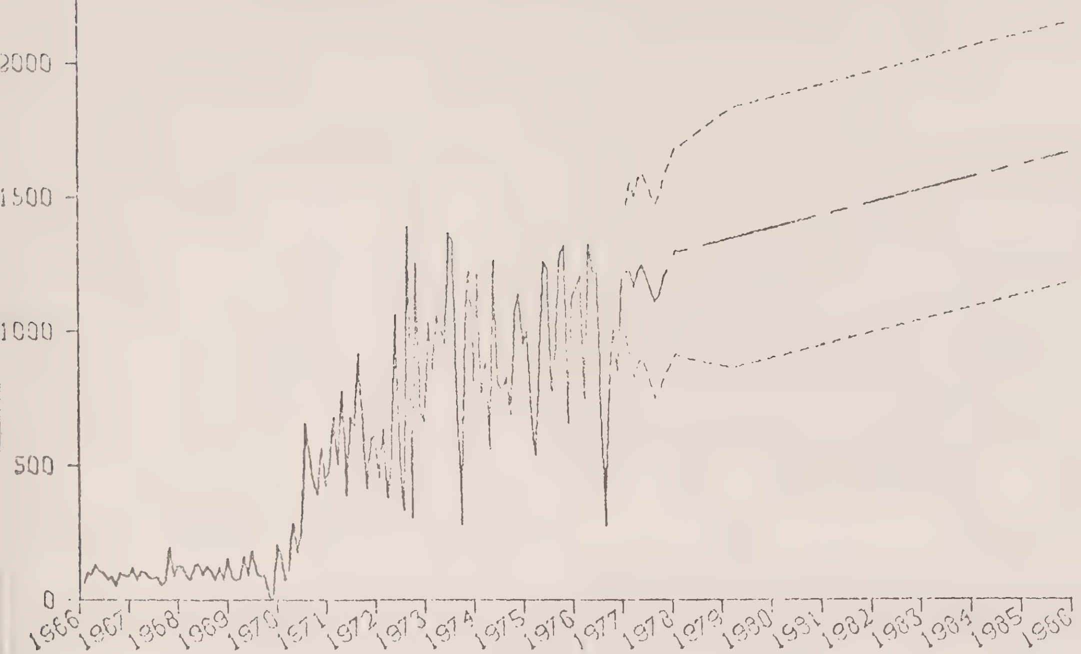
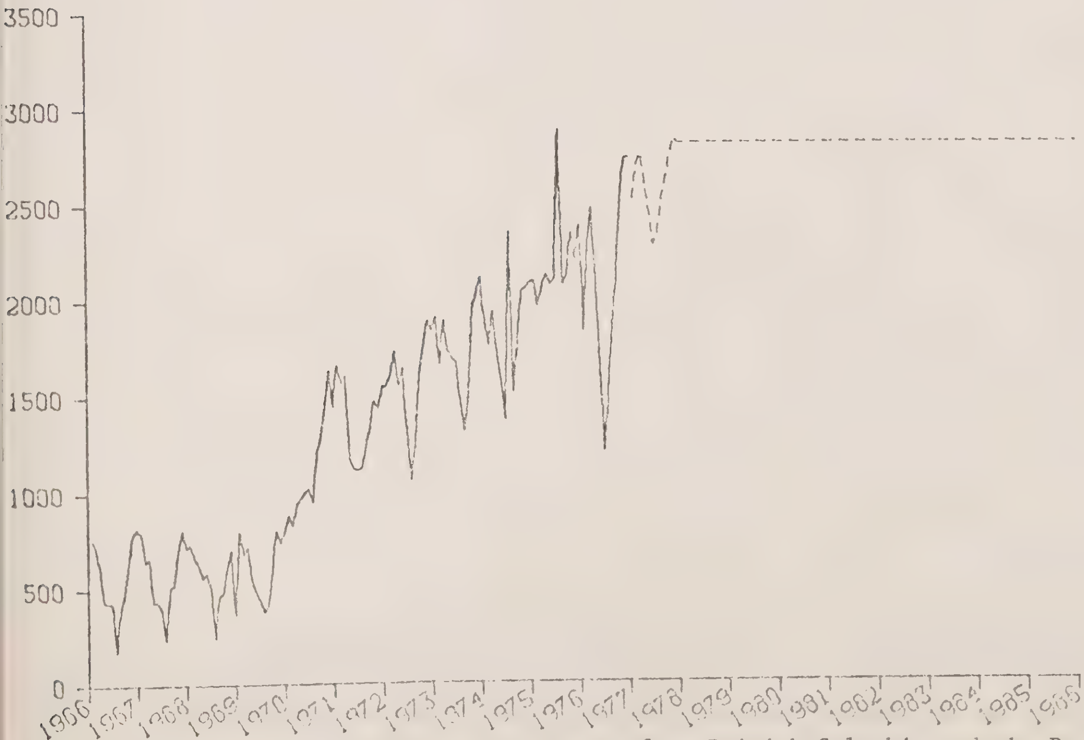


Figure 4.23: A comparison between the monthly exports of Coal from British Columbia to Japan and the monthly Production of Coal of all types from British Columbia and the Prairies

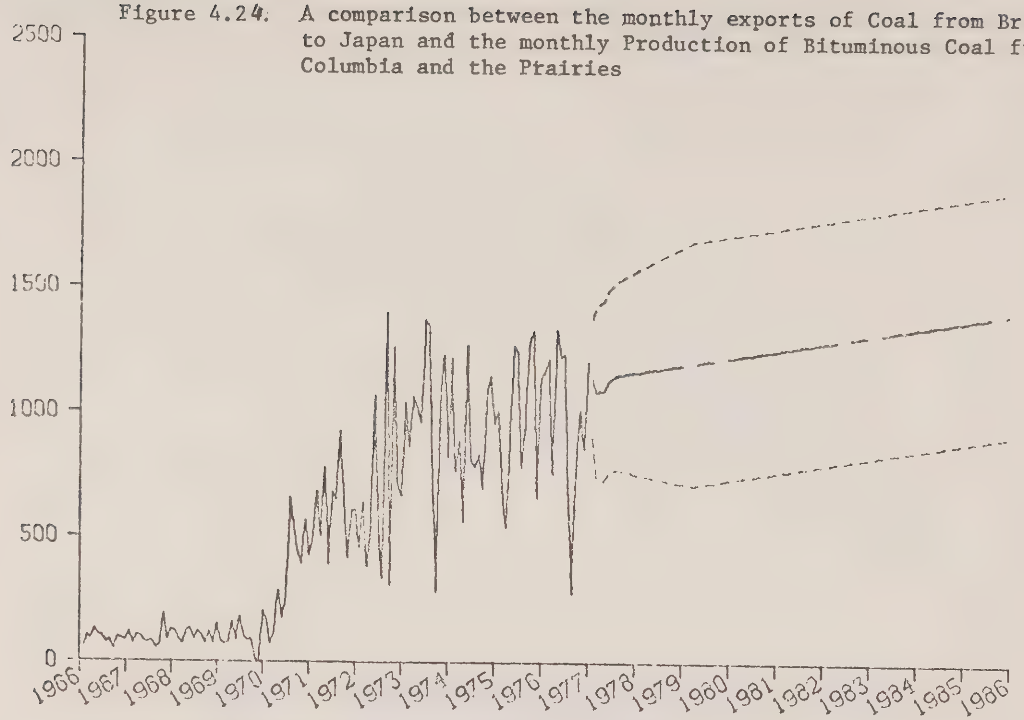


Monthly exports of Coal from British Columbia to Japan in thousands of tons

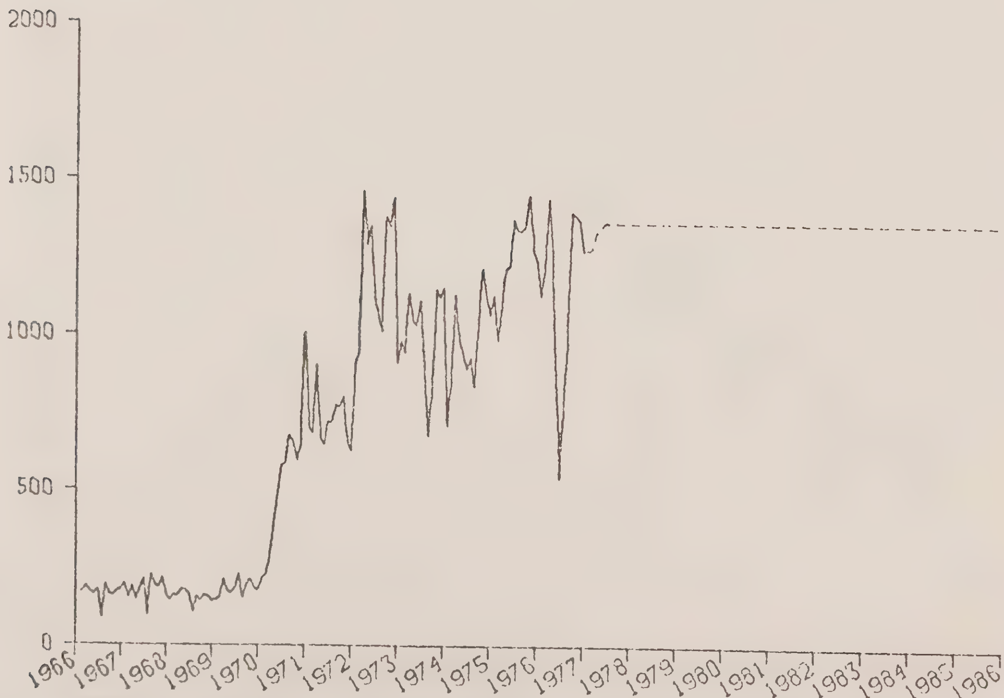


Monthly production of Coal of all types from British Columbia and the Prairies in thousands of tons

Figure 4.24: A comparison between the monthly exports of Coal from British Columbia to Japan and the monthly Production of Bituminous Coal from British Columbia and the Prairies



Monthly exports of Coal from British Columbia to Japan in thousands of tons



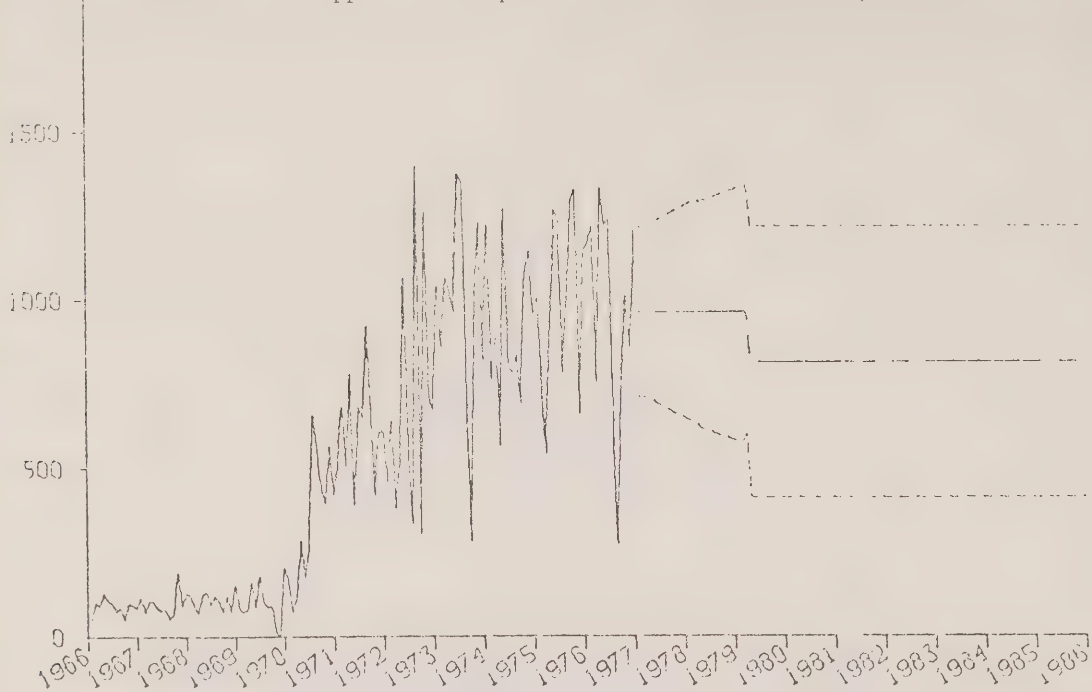
Monthly production of Bituminous Coal from British Columbia and the Prairies in thousands of tons

Figure 4.25: A comparison between the monthly exports of Coal from British Columbia to Japan and the monthly total Crude Steel Production in Japan

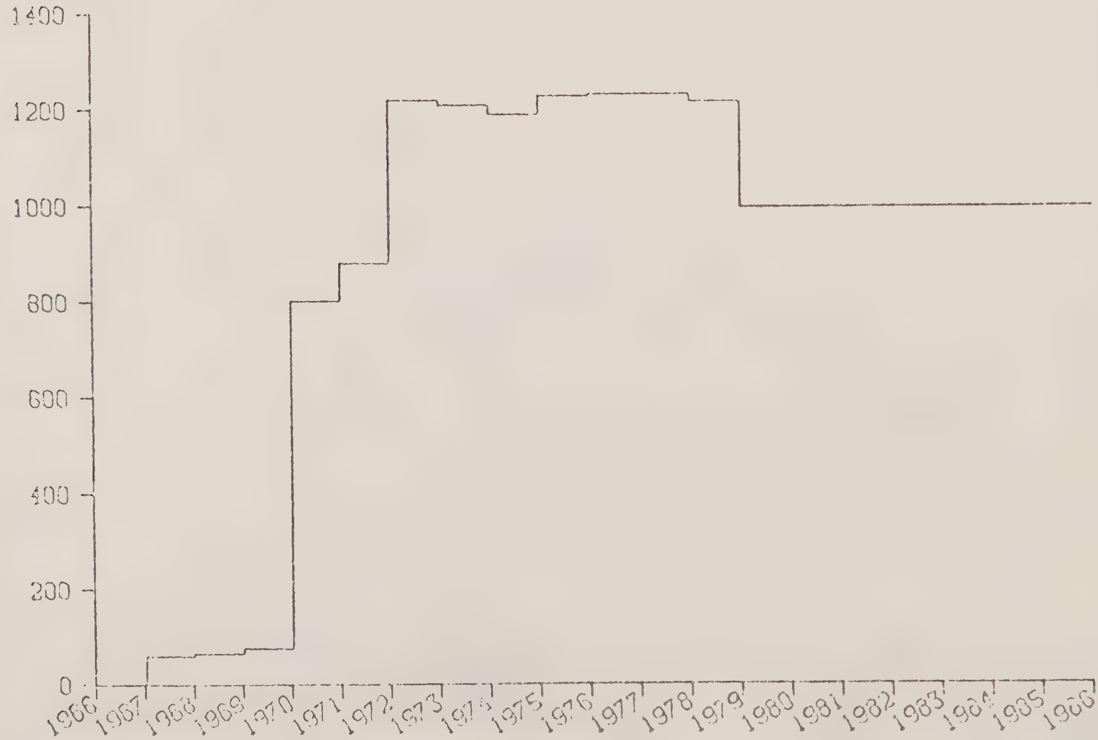
Monthly exports of Coal from British Columbia to Japan in tons

Monthly total Crude Steel Production in Japan in tons

Figure 4.26: A comparison between the monthly exports of Coal from British Columbia to Japan and the average monthly quantities of Coal contracted to be supplied to Japan from Western Canadian producers

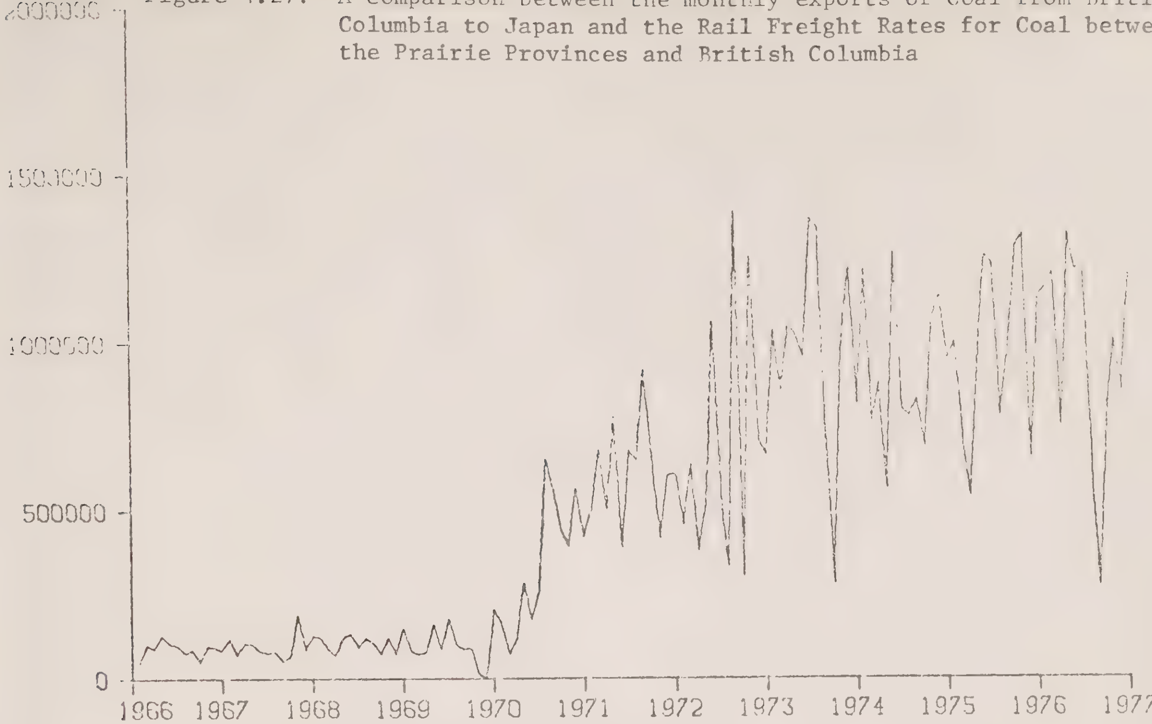


Monthly exports of Coal from British Columbia to Japan in thousands of tons

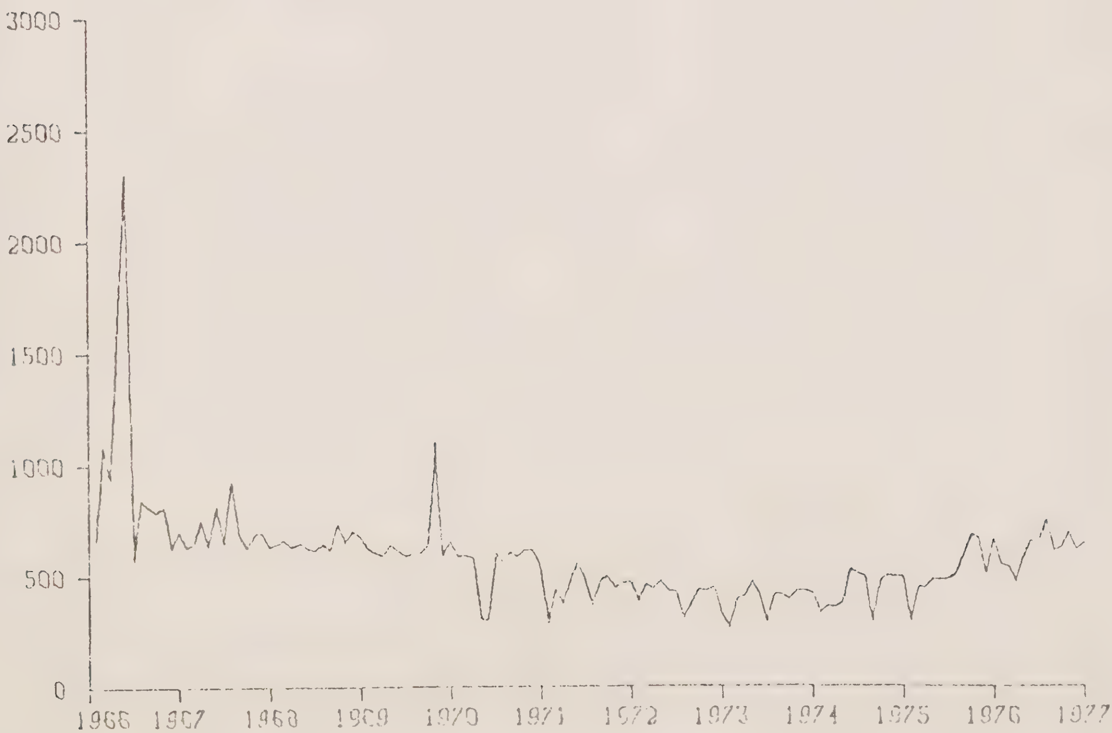


Average monthly quantities of Coal contracted to be supplied to Japan from Western Canadian Producers

Figure 4.27: A comparison between the monthly exports of Coal from British Columbia to Japan and the Rail Freight Rates for Coal between the Prairie Provinces and British Columbia



Monthly exports of Coal from British Columbia to Japan in tons



Monthly Rail Freight Rates for Coal shipped between the Prairie Provinces and British Columbia

Figure 4.28: A comparison between the time series model and the dynamic regression models for the monthly forecasts of the exports of Coal from British Columbia to Japan in thousands of tons

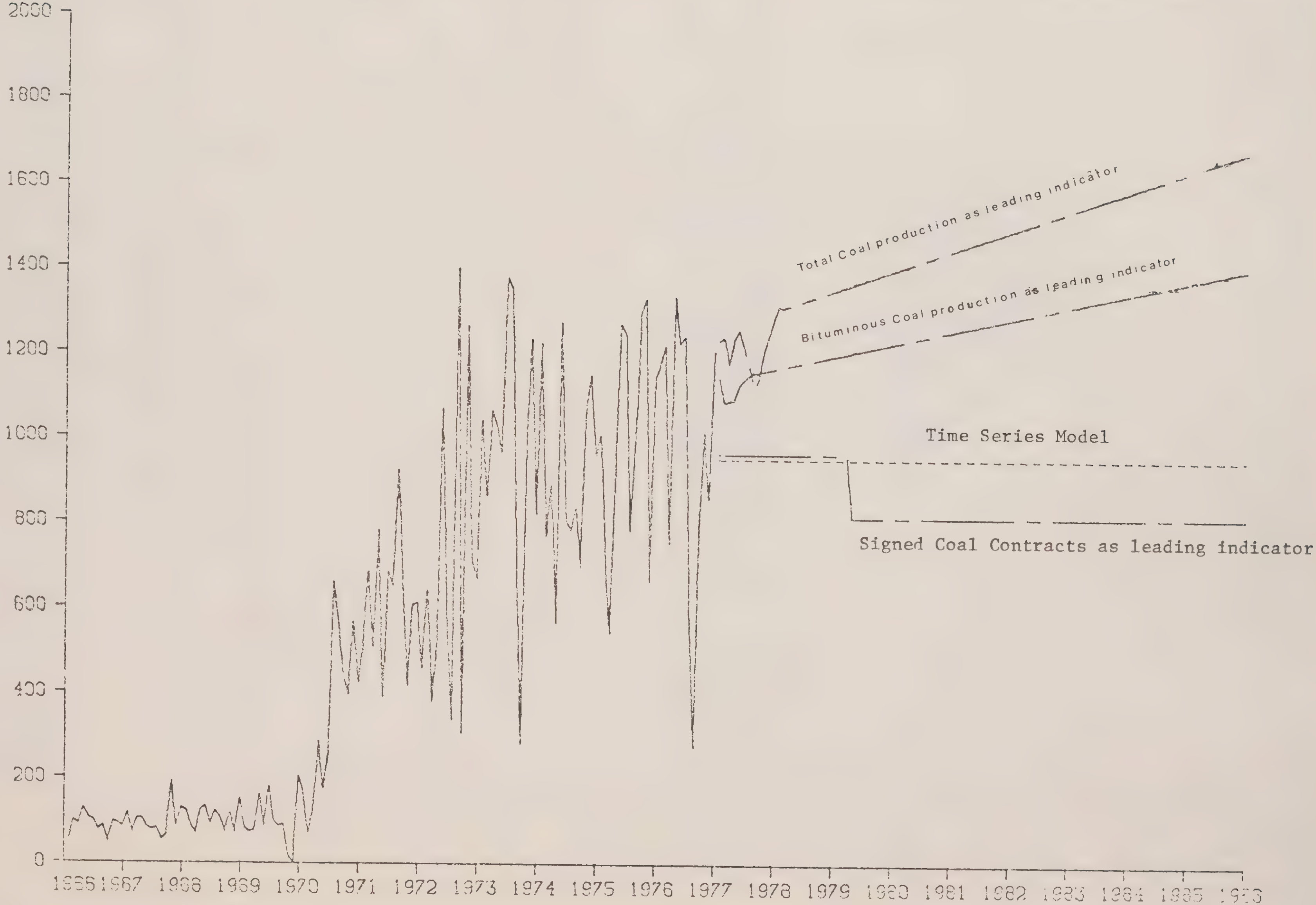
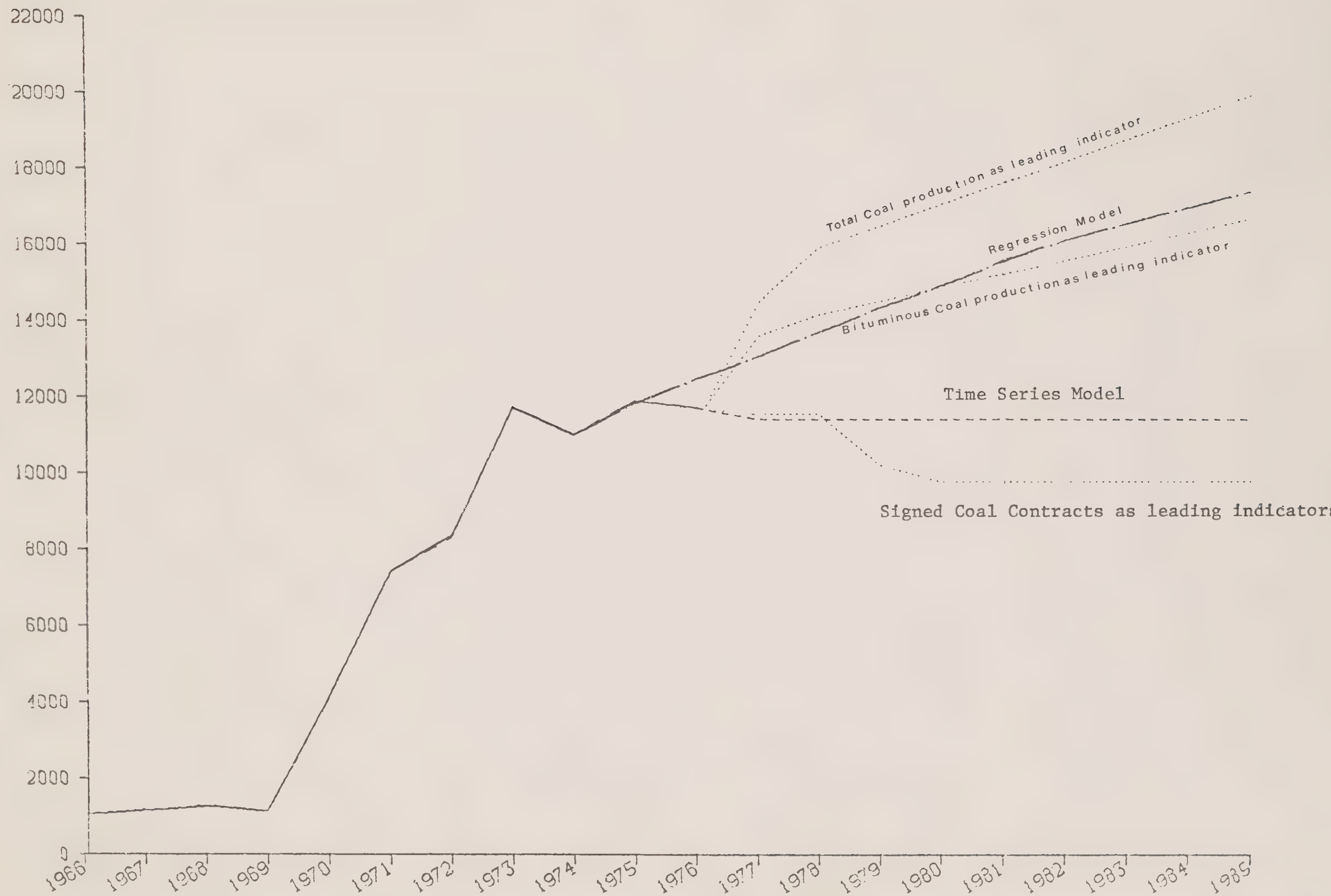


Figure 4.29: A comparison between the time series model, the dynamic regression models and the earlier regression model for the Annual forecasts of the exports of Coal from British Columbia to Japan in thousands of tons



4.11 Rail Movements of Coal from the Prairie Provinces and British Columbia to Ontario.

Data on monthly rail movements of Coal from the Prairie Provinces and British Columbia to Ontario from January 1966 to December 1976 in thousands of tons appear in Figure 4.30. If Z_t represents the movement during month t in millions of tons then Z_t may be described by a moving average time series model

$$\tilde{Z}_t = Z_t - \underset{(\pm 0.012)}{0.033} = (1 + \underset{(\pm 0.166)}{0.287}\, B^2)a_t$$

where the residual standard error is estimated to be 0.0545. Diagnostic checks applied to the residuals indicate that the model is adequate.

The model suggests that the series is stationary about a constant level: the monthly forecasts to December 1985 using this model also appear in Figure 4.30 together with their 75% confidence limits.

As indicated in §4.1, Ontario Hydro has contracted to purchase quite substantial quantities of Coal from the Prairie Provinces and British Columbia as part of its plan to diversify its sources of Coal. The large movement during the summer of 1975 as seen in Figure 4.30 was a result of the program. The average monthly quantities of Coal contracted to be supplied to Ontario Hydro by Coal producers in British Columbia and the Prairie Provinces[1] appear in Figure 4.31. If X_t represents this series then it is clear from Figure 4.31 that little is to be gained by a comparison between X_t and Z_t for the observed period from January 1966 to December 1976. In the absence of any data from which to estimate a dynamic regression model between X_t and Z_t, it was assumed that the model was identical to the model in §4.10 where signed Coal

[1] Coal Canada: Focus 3 February 1978.

Contracts were used as a leading indicator of Coal exports from British Columbia to Japan, namely

$$\nabla Z_t = 0.631 \nabla X_{t-3} + (1 - 0.940 B)a_t$$

and monthly forecasts of Coal movement to December 1985 using this model appears in Figure 4.31: note that confidence limits are unavailable owing to a limitation of the computer software in this particular situation.

The additional effect of Rail Freight Rates for Coal[2] from British Columbia and the Prairies to Ontario on the monthly movements of Coal was examined: the Rail Freight Rates, adjusted by a GNP deflator, appear in Figure 4.32. The two series do not appear related and the process of developing a dynamic regression model fails to indicate any significant Transfer Function between the two series.

A comparison between the monthly forecasts from the time series model and the dynamic regression model appears in Figure 4.33 while data and forecasts, on an annual basis, from the time series model, the dynamic regression model and the earlier regression model appear in Figure 4.34. In Table 4.16 we present the data and annual forecasts obtained from the dynamic regression model using the Coal Contracts as leading indicator. These forecasts are not strictly comparable with the other forecasts owing to the quite different assumptions which provide the basis for their calculation. In passing it has been suggested that the contractual arrangements between Ontario Hydro and the Western Canadian Coal producers are less likely to be subject to later alteration than the contractual arrangements between the Western Canadian Coal producers and the Japanese upon which the model is based.

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[2] Compiled from Computer Tapes which are summarised in 'Waybill Analysis: Carload All-Rail Traffic' Canadian Transport Commission.

Table 4.16: Annual rail movements of Coal from British Columbia and the Prairie Provinces to Ontario in thousands of tons: the forecasts were derived from the dynamic regression model using the Coal Contracts as a leading indicator.

Year	Data	Year	Forecasts
1966	255	1978	280
67	307	79	1,794
68	209	80	2,377
69	158	81	2,377
70	628	82	2,535
71	145	83	2,535
72	593	84	2,535
73	66	85	2,535
74	526		
75	929		
76	521		

Figure 4.30: Monthly rail movements of Coal from the Prairie Provinces and British Columbia to Ontario in thousands of tons

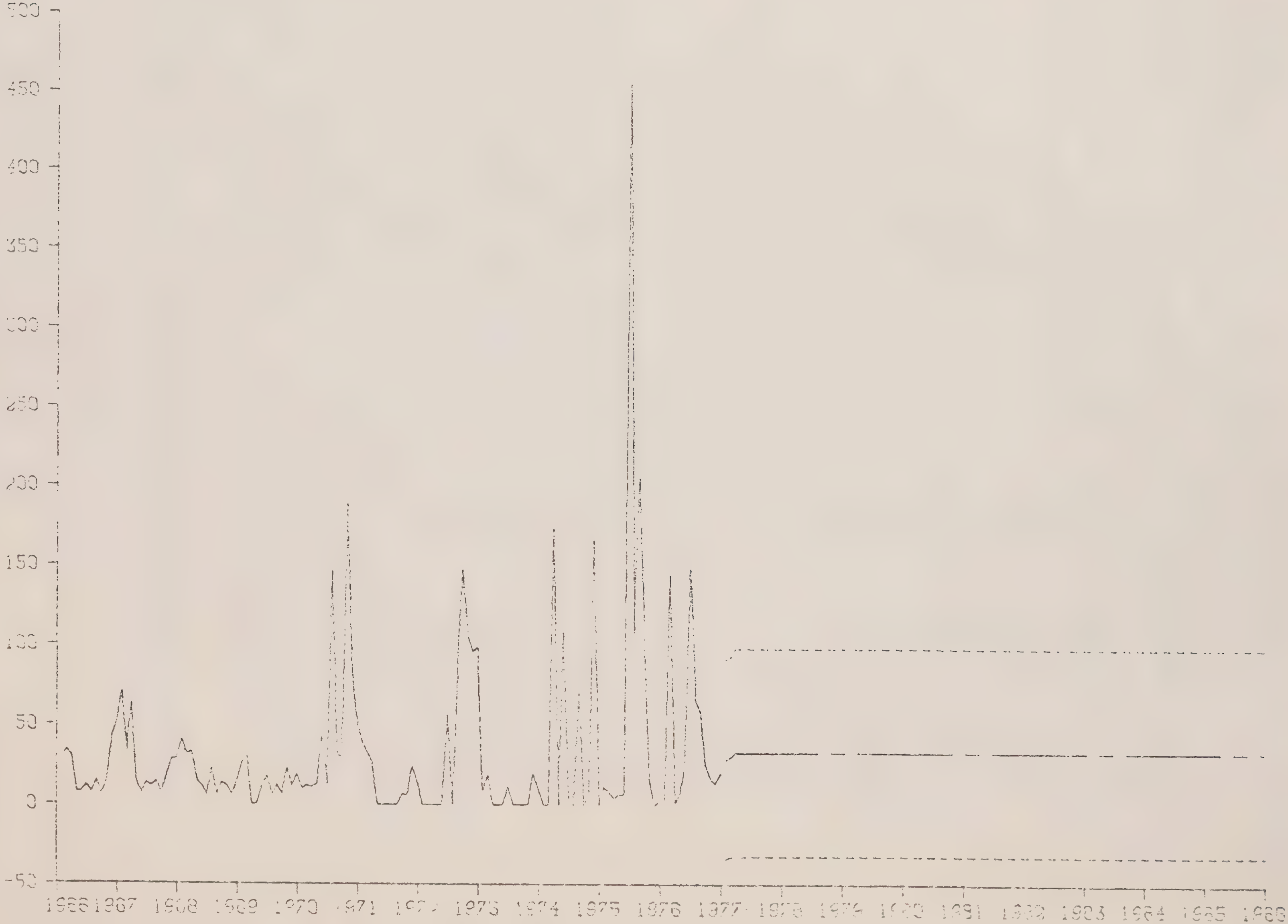
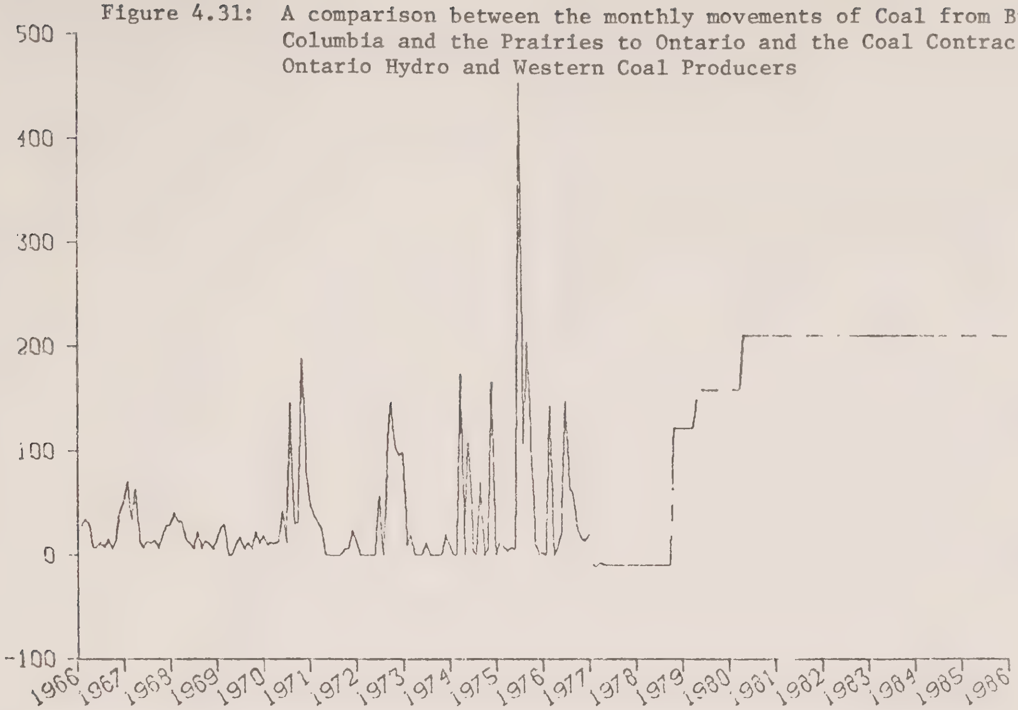
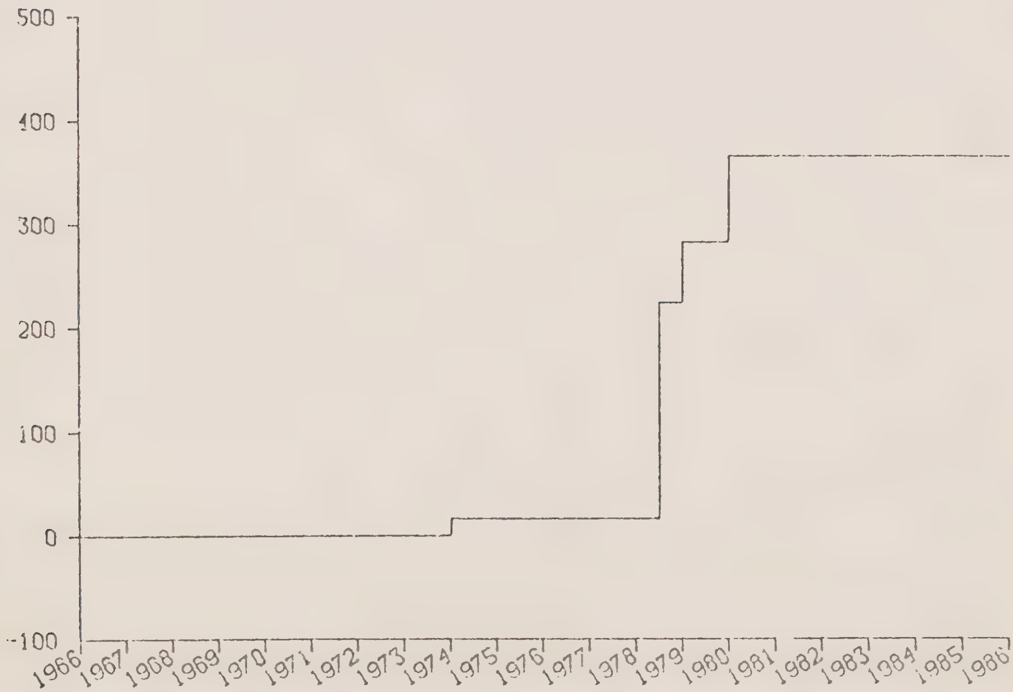


Figure 4.31: A comparison between the monthly movements of Coal from British Columbia and the Prairies to Ontario and the Coal Contracts between Ontario Hydro and Western Coal Producers

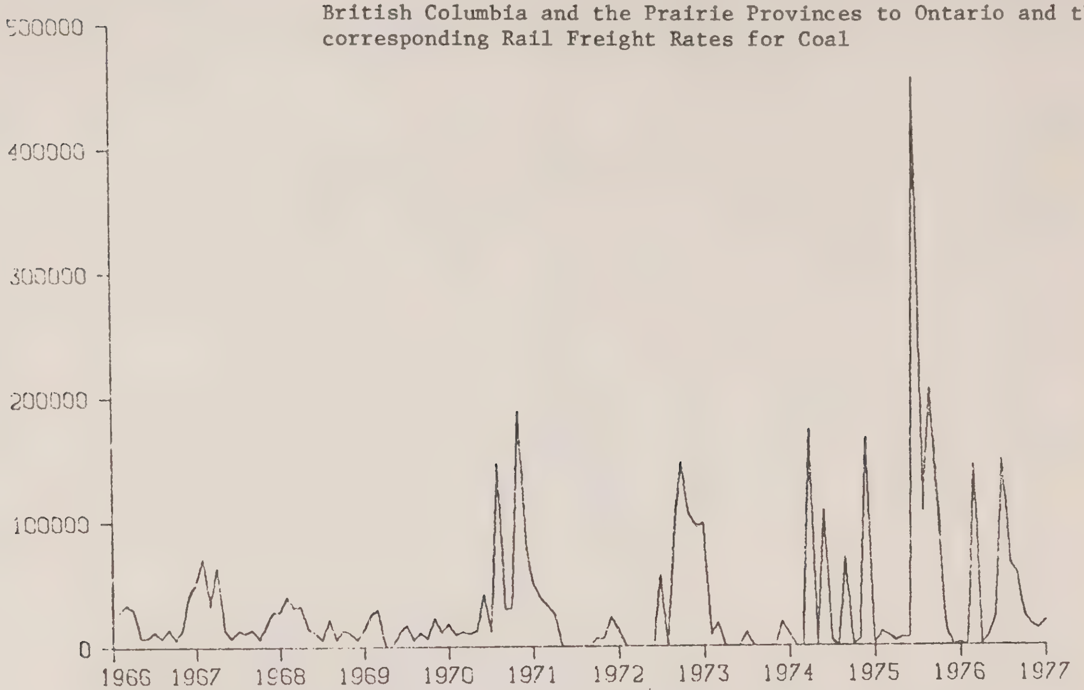


Monthly movements of Coal from British Columbia and the Prairie Provinces to Ontario in thousands of tons

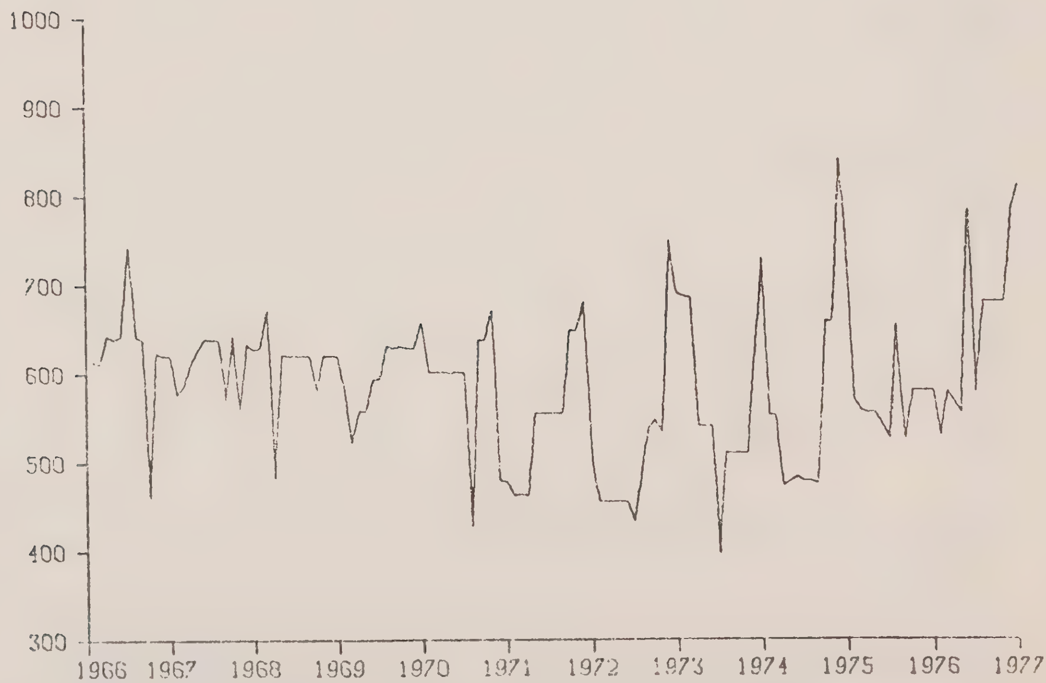


Average monthly quantity of Coal contracted to be supplied to Ontario Hydro by Western Coal Producers

Figure 4.32: A comparison between the monthly rail movements of Coal from British Columbia and the Prairie Provinces to Ontario and the corresponding Rail Freight Rates for Coal



Monthly rail movements of Coal from British Columbia and the Prairie Provinces to Ontario in tons



Monthly Rail Freight Rates for Coal shipped from British Columbia and the Prairie Provinces to Ontario

Figure 4.33: A comparison between the time series model and the dynamic regression model for the monthly forecasts of rail movements of Coal from British Columbia and the Prairie Provinces to Ontario in thousands of tons

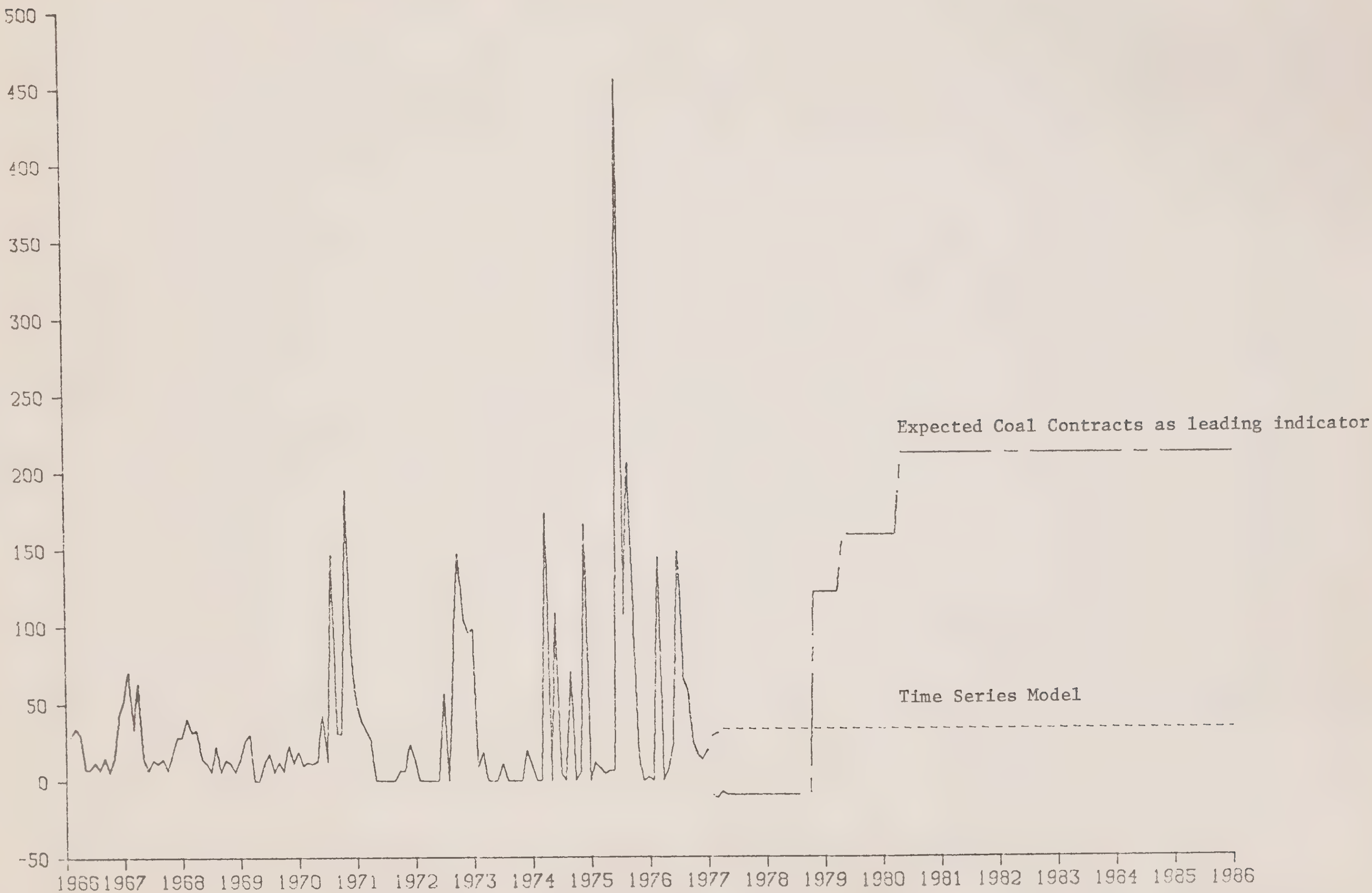
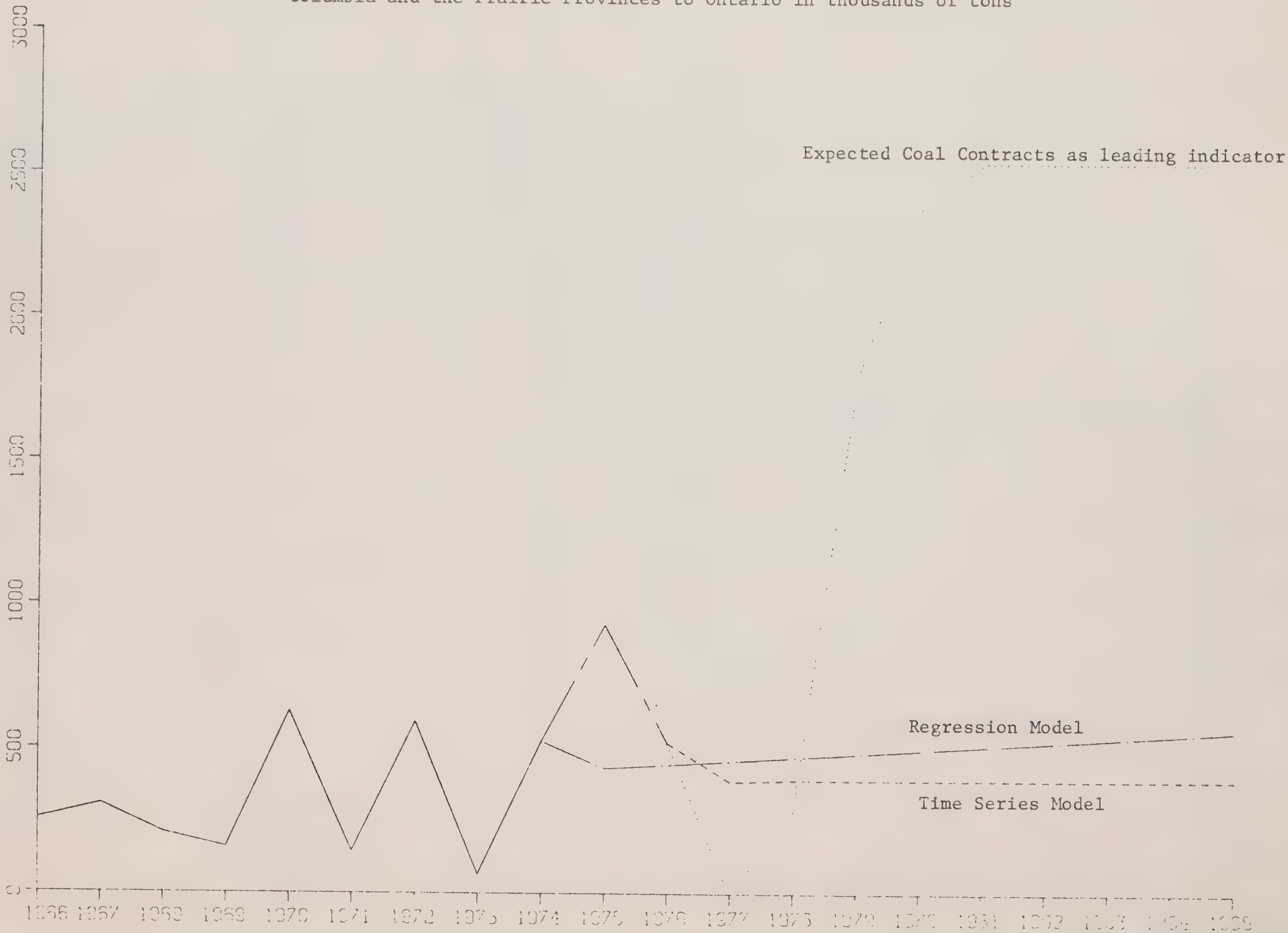


Figure 4.34: A comparison between the time series model, the dynamic regression model and the earlier regression model for the Annual forecasts of the rail movements of Coal from British Columbia and the Prairie Provinces to Ontario in thousands of tons



Chapter 5

The Transportation of Newsprint

5.1 Analysis

Canada is the world's largest producer of Newsprint with 8.9 million short tons produced in 1976, representing 38% of total world output. This percentage share has dropped from a high of 41% in previous years. Within Canada Quebec is the largest producer with 46.8% of total production (1971-1975) followed by Ontario with 20%. The Atlantic Region and British Columbia each account for _ 15.8%. In the past, increases in production tended to be followed by a mild slump: a sharp rise in prices caused by inflationary pressure led to a peak production in 1974 of 9.6 million tons while labour difficulties and a sudden decrease in world demand resulted in a marked decline in 1975 to a level of 7.7 million tons.

Newsprint constitutes the largest single paper product of the Canadian pulp and paper industry. It is produced mainly from low cost mechanical wood pulp (supplemented by some chemical pulp, sulphite and kraft) in some 43 mills owned by 21 companies which are estimated to be 57% Canadian controlled. Mills owned by Newspaper Publishers now represent about 11% of the total number, up from 8% in the 1960's.

Suppliers generally sign 3 to 5 year contracts with publishers. This allows for stabler long-term planning. Option clauses are included to provide for re-negotiation on an annual or even semi-annual basis. Both parties therefore have the opportunity to adjust to fluctuating market conditions. During the life of the contracts, the customers usually buy a base amount annually, such as 10,000 tons, at a fixed price and incremental shipments are delivered at prices negotiated at the time of purchase.

Since 1973, the annual productive capacity of about 10.3 million tons has remained fairly stable. A major factor affecting the expansion of capacity and hence production and shipments is the drop in the basis weight of Newsprint from 32 lbs. per 3,000 square feet down to the current 30 lb. range. The projection is for a further reduction with possibly more than 27% of all Newsprint having a basis weight at or below 28 lbs. by 1980 and 42% by 1990. As a result, an annual growth rate of no more than 2% in production by weight is envisaged for the next few years.

Costs of energy, pollution abatement equipment and transportation, together with resource conservation measures have adversely affected the price/cost ratio for Newsprint, thus further limiting the addition of capacity using new facilities. The accent is on marginal increments in capacity and on cost reduction through optimization and modernization since

optimization costs per annual increment in capacity have been estimated to be approximately 60% of the costs of building new facilities. This involves upgrading present equipment, incorporating new technology and improving the balance between the various mill components. An example is the introduction of a new thermo-mechanical pulping process which is not however expected to significantly affect present production methods in Canada until at least 1990. Note that the location of major population centres in Canada does not favour the economical establishment of mills based on recycled waste newspapers.

Domestic consumption of Newsprint is relatively small, averaging about 8% of total production (1971-1975). Ontario accounts for 33% of this domestic consumption while Quebec accounts for another 30% and the Prairie Provinces, British Columbia and the Atlantic Provinces account for 17%, 13% and 7% respectively. Over 90% of Canadian newsprint is exported annually and it is essentially a tariff-free commodity. The United States receives more than 80% of these exports and Western Europe and Latin America each account for about 7%.

The annual shipments of some 6.4 million tons to the United States (1971-1975) represent over 60% of United States Newsprint consumption. Although total tonnages have not

exhibited a definite downward trend, this percentage share has declined over the past decade due to capacity increases in the southern U.S. mills. These mills have only a 15% share of the market but they have a competitive edge over Canadian suppliers and shippers because of factors such as shorter hauls, easier access to the larger consuming areas, lower labour rates and lower wood costs. Overall, the growth in both Canadian and United States Newsprint consumption has experienced a decline from a rate of about 5% prior to 1970 to the present rate of less than 3%. It is expected that future marginal increases in United States consumption will be supplied by the mills in the south.

Over 80% of the 580,000 tons shipped annually (1971-1975) to Western Europe was destined for the United Kingdom. However, Canada's share of the U.K. imports has dropped from over 60% in the early 1960's to 35% and less since 1974 as there is a tendency for markets in Western Europe to prefer Scandinavian Newsprint. Shipments to Latin America have averaged 544,000 tons annually (1971-1975) but their expressed désire for self-sufficiency in Newsprint coupled with preference for the products of members of the Latin American Free Trade Association may serve to limit sale increases to that part of the world. Efforts aimed at market diversification in other areas have

however helped to offset decreases caused by local recessions, competition or bilateral trade agreements such as the New Zealand - Australia Free Trade Agreement which imposed a tariff on imported Canadian Newsprint in excess of the duty free quota.

Considering the average of 8 million tons of Newsprint shipped annually in 1971 to 1975: some 4.3 million tons (53%) were carried by rail, 3.2 million tons (40%) by marine and 0.5 million tons (7%) by truck. Note that vessel charter is the predominant and most economical method of arranging for shipments to offshore foreign markets. Movements to the United States are dominated by the rail mode, which accounts for 66% of the annual transborder flow of 6.4 million tons (1971-1975), while Marine movements account for 26% and Trucking accounts for the remaining 8%.

Approximately 2 million tons of Newsprint were moved by rail through the Windsor-Sarnia and Buffalo gateways. Some rail cars carrying Newsprint from Northern Ontario were ferried across Lake Superior from Thunder Bay to Duluth and the United States Midwest cities. About 1.6 million tons were shipped by rail through the Eastern Townships in Quebec. Rail shipments via Manitoba totalled 330,000 tons annually while an equal amount went from British Columbia to the Western United States.

Rail freight to the United States usually moves through joint rates that are negotiated with both Canadian and U.S. railways. For Canadian suppliers, rail transport costs can account for 15% of the selling price of Newsprint in the Eastern United States. Suppliers, carriers and the Canadian Government have studied the possibility of moving Newsprint cars by trainload and distributing the Newsprint by truck from central warehouses in order to reduce overall cost. It was concluded that, although line haul savings would be realized, the increases in warehousing, inventory and local transport costs would outweigh the savings.

Of the 1.6 million tons of marine flows to the United States in 1975, 800,000 tons were carried from the Atlantic and St. Lawrence ports to the Eastern and Southern United States. Approximately 200,000 tons were moved through the Seaway and across the Great Lakes while the remaining 600,000 tons were shipped from British Columbia ports to the Western United States.

Domestic marine flows amounted to 370,000 tons and most of these movements occurred on the west coast. As a whole

coastal marine flows have decreased from over 500,000 tons in 1971 to under 300,000 tons in 1976. Problems of stevedoring and delays in transit time, have accelerated the decline in the volume carried and modal substitution, particularly by rail, is becoming apparent.

The Atlantic ports of Botwood, Cornerbrook, Liverpool, St. John and Dalhousie are the main Newsprint ports in that region while Baie Comeau, Quebec City, Port Alfred and Trois Rivieres handle most of the Newsprint marine movements in Quebec. Thunder Bay is the only significant port shipping Newsprint across the Great Lakes to the United States. In British Columbia, Powell River, Port Alberni and Campbell River account for most of the marine Newsprint flows. Large warehouses for Newsprint (over 10,000 tons) do not exist on or near Canadian mills. The major ones are located in consuming areas such as New York, Newport News, Norfolk, Baltimore, Richmond and Alexandria (Washington, D.C.) in the Eastern United States and Rochester, Buffalo, Cleveland, Toledo, Detroit, Milwaukee, Chicago and Muskegon along the Great Lakes.

The 500,000 tons carried by trucks were mainly from Quebec for distances of 500 miles or less. Trucking generally offers more flexible service at competitive rates and eliminates some of the transit damage problems associated

with rail transport. Thus, this mode is important for moving Newsprint to the domestic areas of consumption. Note that the choice of mode and route is usually determined by the consumer and a particular rail-ferry-rail route may be preferred because it provides the fastest delivery from the mills even though it may not be the most economical.

The time series analysis was applied to 11 major Newsprint links. These represented the rail and marine export flows from the 5 Canadian regions to the U.S. and the marine flows from the Atlantic region and Quebec to Western Europe and Latin America. The observed monthly data extended from January 1966 to December 1975. Once appropriate time series models were estimated, monthly forecasts were calculated from January 1976 to December 1985. The monthly forecasts were aggregated into annual figures and compared with the results from the earlier regression model. The latter also used Newsprint flow data from External Trade although only annual observations up to 1974 were used.

The earlier regression model employed Newsprint production and Newsprint consumption as explanatory variables with local trucking activities included in some links. For the forecast period to 1985 Newsprint production was obtained indirectly from CANDIDE, the macroeconomic model of the Canadian Economy constructed by the Economic Council of Canada. Newsprint consumption and trucking data were projected from time trends.

5.2 Rail Movements of Newsprint from the Atlantic Provinces to the United States.

Data on monthly rail movements of Newsprint from the Atlantic Provinces to the United States from January 1966 to December 1975 in thousands of tons appear in Figure 5.1. The upward trend in the observed period may be due more to mode switching from marine to rail than to sustained increases in demand for Newsprint. If Z_t represents the movement during month t in millions of tons, then Z_t may be described by a mixed autoregressive - moving average time series model[1]

$$(1 - \underset{(\pm 0.271)}{1.334}\, B + \underset{(\pm 0.268)}{0.331}\, B^2)\tilde{Z}_t = (1 - \underset{(\pm 0.173)}{0.832}\, B)a_t$$

$$\tilde{Z}_t = Z_t - \underset{(\pm 0.007)}{0.008}$$

with the residual standard error estimated to be 0.0051. Diagnostic checks applied to the residuals indicate the model is satisfactory.

The model indicates that the data is non-stationary with no seasonal component: monthly forecasts to December 1985 using this model also appear in Figure 5.1 together with their 75% confidence limits. The absence of seasonality in the model indicates that rail movements in the Atlantic Provinces are not adversely affected by climatic conditions. The model has captured the underlying upward trend in the data and the forecast shows a compound annual growth rate of about 4.4% for this link.

The data and forecasts on an annual basis are given in Table 5.1 and are compared with data and forecasts from the earlier regression model in Figure 5.2. Both models use the same data source up to 1974 and, apart from a drop in 1975, both exhibit essentially the same upward trend in the forecasts.

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[1] For details of notation see Chapter 2: the numbers in parentheses indicate 95% confidence limits as mentioned previously.

Table 5.1: Annual rail movements of Newsprint from the Atlantic Provinces to the United States in thousands of tons: the forecasts were derived from the Time Series Model

Year	Data	Year	Forecasts
1966	93	1978	390
67	96	79	400
68	137	80	420
69	185	81	440
70	188	82	460
71	235	83	480
72	234	84	500
73	400	85	530
74	427		
75	369		

Figure 5.1: Monthly rail movements of Newsprint from the Atlantic Provinces to the United States in thousands of tons

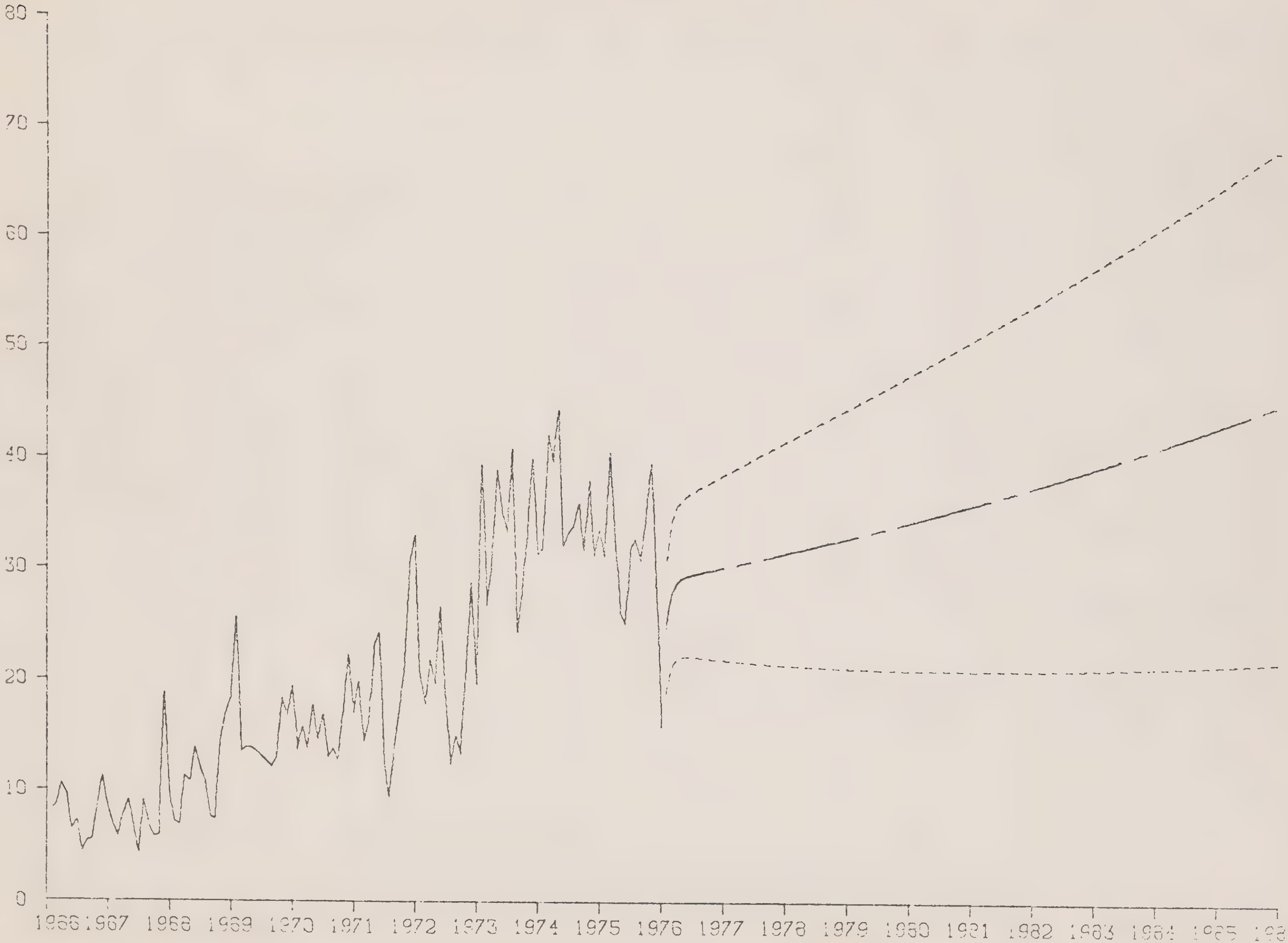
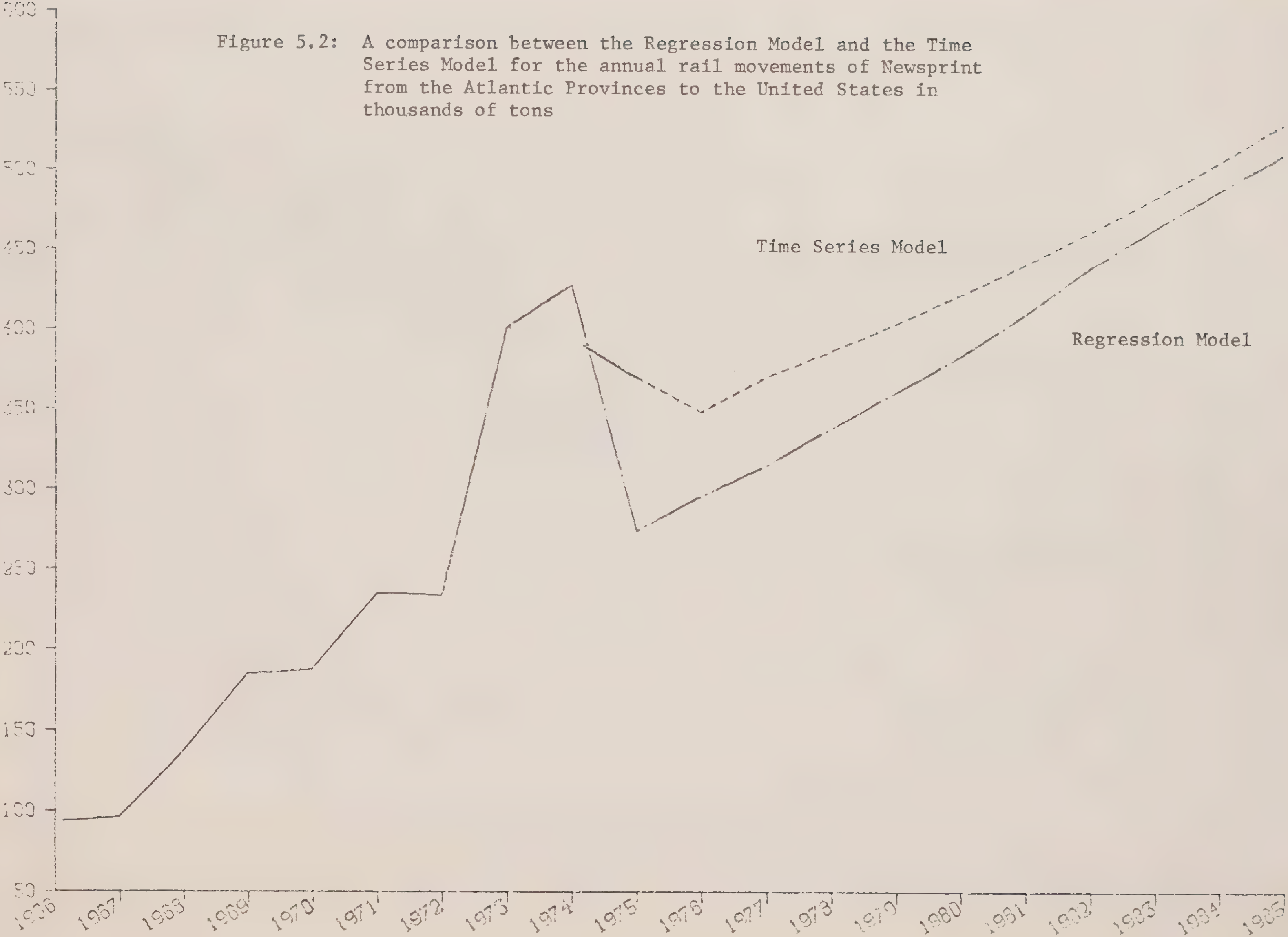


Figure 5.2: A comparison between the Regression Model and the Time Series Model for the annual rail movements of Newsprint from the Atlantic Provinces to the United States in thousands of tons



5.3 Rail Movements of Newsprint from Quebec to the United States

Data on monthly rail movements of Newsprint from Quebec to the United States from January 1966 to December 1975 in thousands of tons appear in Figure 5.3. The observed points do not indicate any clear trend. Notice the low movements during 1973 and 1976. If Z_t represents the movement during month t in millions of tons, then Z_t may be described by a multiplicative seasonal time series model

$$(1 - \underset{(\pm 0.171)}{0.466}\, B)\tilde{Z}_t = (1 + \underset{(\pm 0.192)}{0.206}\, B^{12})a_t$$

$$\tilde{Z}_t = Z_t - \underset{(\pm 0.010)}{0.170}$$

and the residual standard error is estimated to be 0.0254. Diagnostic checks applied to the residuals indicate the model is satisfactory.

The model suggests that the data is stationary with a secondary seasonal component: monthly forecasts to December 1985 using this model also appear in Figure 5.3 together with their 75% confidence limits.

The data and forecasts on an annual basis are given in Table 5.2 and are compared with data and forecasts from the earlier regression model in Figure 5.4. The regression model, using similar data up to 1974 showed a strong upward growth in the forecasts from 2.46 million tons in 1974 to 4.3 million tons by 1985. This was due to the fact that the rail movement was estimated to be an increasing function of Quebec Newsprint production and United States consumption both of which were projected to increase.

In view of what has been mentioned about the possible slow down in growth in production and consumption of Newsprint in Canada and the U.S., the results of the time series analysis might present a more realistic view of future flows along this link.

Table 5.2: Annual rail movements of Newsprint from Quebec to the United States in thousands of tons: the forecasts were obtained from the time series model

Year	Data	Year	Forecasts
1966	1,792	1978	2,030
67	1,866	79	2,030
68	1,770	80	2,030
69	2,122	81	2,030
70	2,139	82	2,030
71	2,038	83	2,030
72	2,150	84	2,030
73	2,136	85	2,030
74	2,464		
75	2,006		

Figure 5.3: Monthly rail movements of Newsprint from Quebec to the United States in thousands of tons

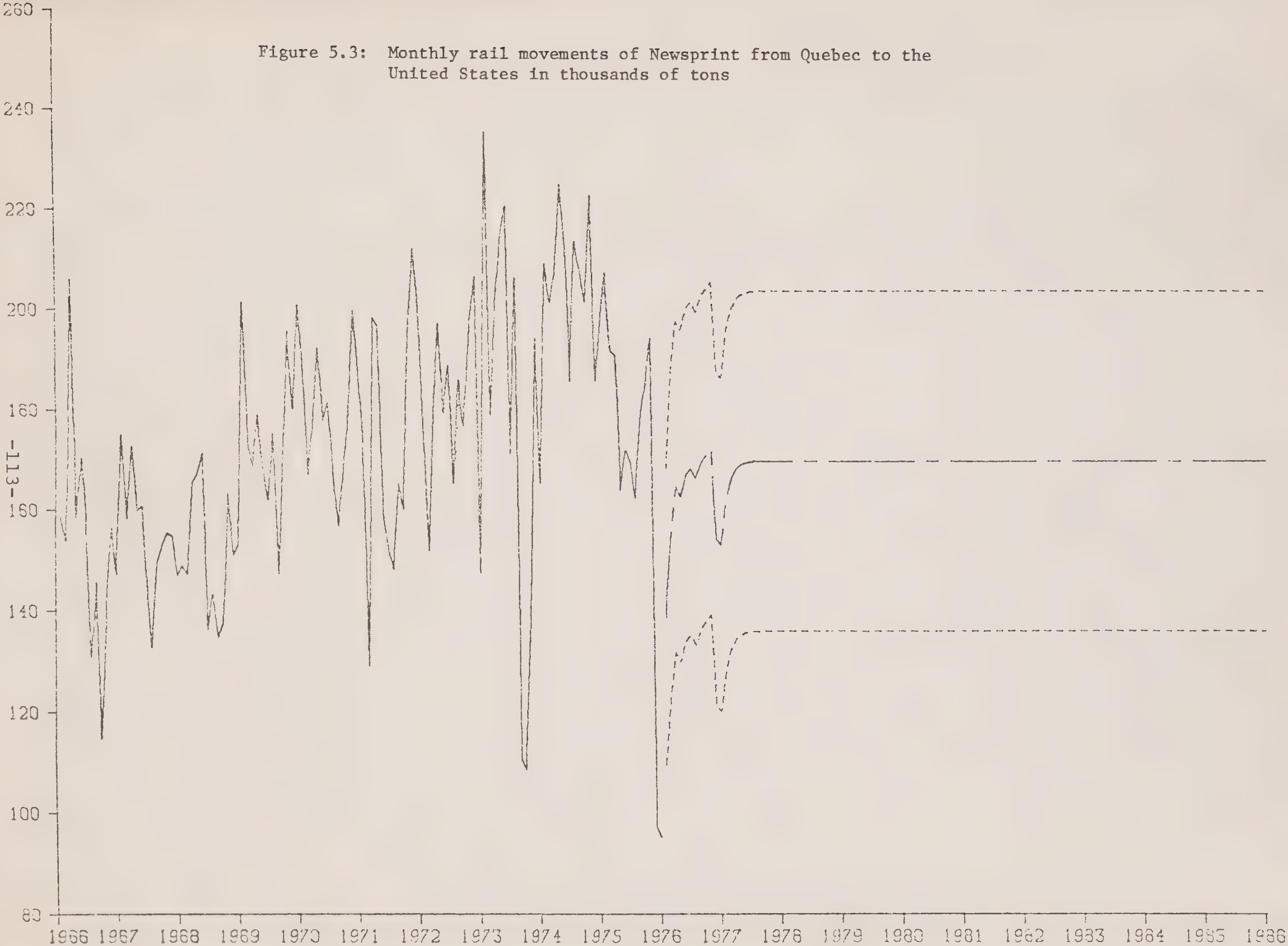
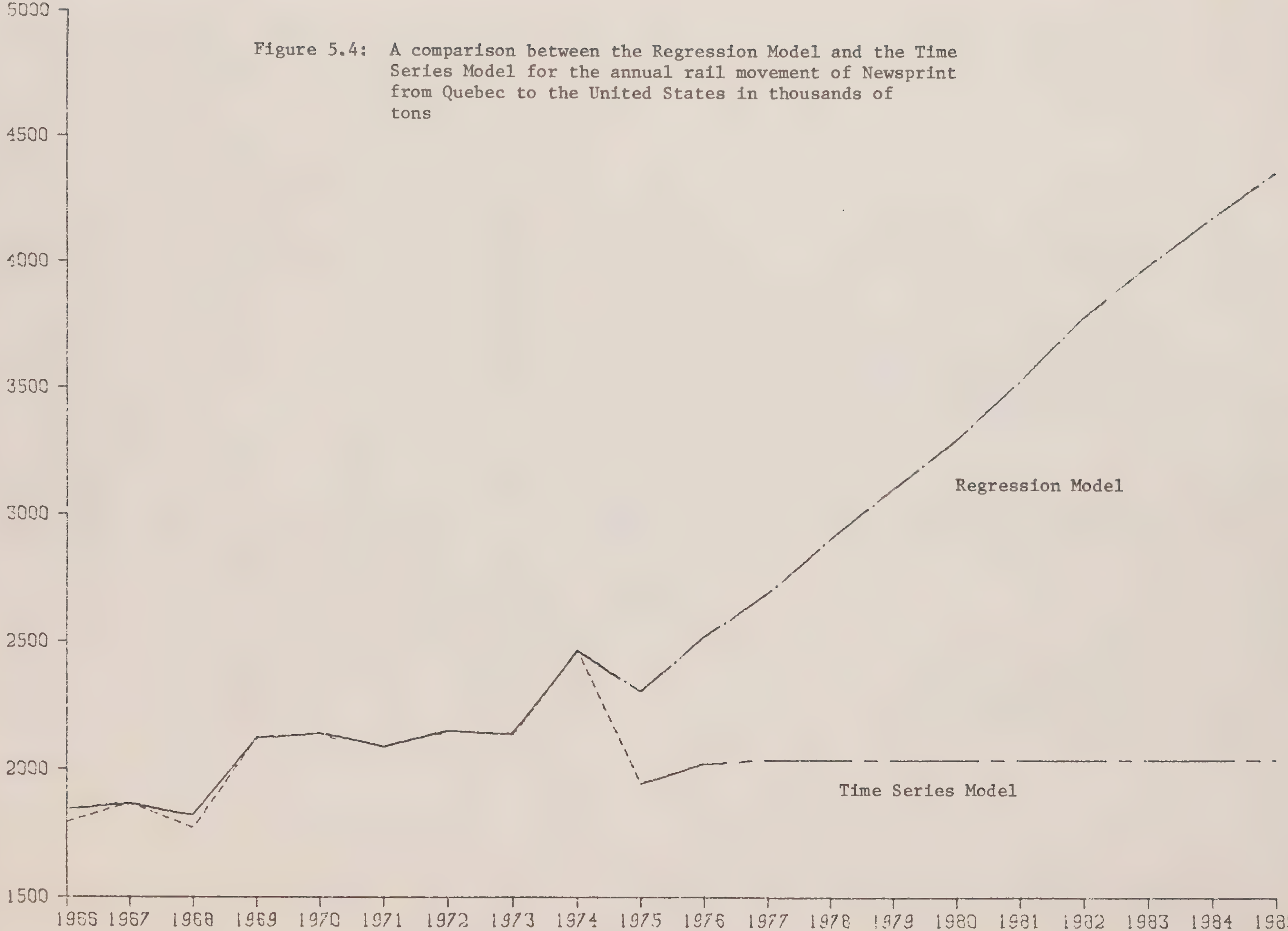


Figure 5.4: A comparison between the Regression Model and the Time Series Model for the annual rail movement of Newsprint from Quebec to the United States in thousands of tons



5.4 Rail exports of Newsprint from Ontario to the United States.

Data on monthly rail exports of Newsprint from Ontario to the United States from January 1966 to December 1975 in thousands of tons appear in Figure 5.5. Notice the very low movement in 1975 which is considered in part to reflect Labour difficulties and a sudden downturn in the world Newsprint market. If Z_t represents the movement during month t in millions of tons, then Z_t may be described by a multiplicative seasonal time series model

$$\underset{(\pm 0.141)}{(1 - 0.771\, B)}\ \underset{(\pm 0.202)}{(1 - 0.318\, B^{12})}\tilde{Z}_t = a_t$$

$$\tilde{Z}_t = Z_t - \underset{(\pm 0.021)}{0.103}$$

and the residual standard error is estimated to be 0.0181. Diagnostic checks applied to the residuals indicate a marginally significant value of the autocorrelation function at lag 10 but otherwise the model is judged adequate.

The model suggests that the data is stationary with a secondary seasonal component: monthly forecasts to December 1985 using this model also appear in Figure 5.5 together with their 75% confidence limits. The model forecasts a recovery from 0.85 million tons in 1976 to an approximately constant annual level of 1.24 million tons by 1982.

The data and forecasts on an annual basis are given in Table 5.3 and are compared with data and forecasts from the earlier regression model in Figure 5.6. Although based on similar observed data, the regression model gave a very different forecast picture, that of an increase from 1.63 million tons in 1974 to 2.6 million tons by 1985. Again the predicted increases in the explanatory variables lead to the sustained growth. The latest indications of economic activity

suggest that levels of movement indicated by the time series analysis are more likely.

Table 5.3: Annual rail exports of Newsprint from Ontario to the United States in thousands of tons: the forecasts were obtained from the time series model.

Year	Data	Year	Forecasts
1966	1,279	1978	1,190
67	1,313	79	1,220
68	1,273	80	1,230
69	1,313	81	1,230
70	1,238	82	1,230
71	1,175	83	1,230
72	1,191	84	1,240
73	1,490	85	1,240
74	1,627		
75	1,059		

Figure 5.5: Monthly rail exports of Newsprint from Ontario to the United States in thousands of tons

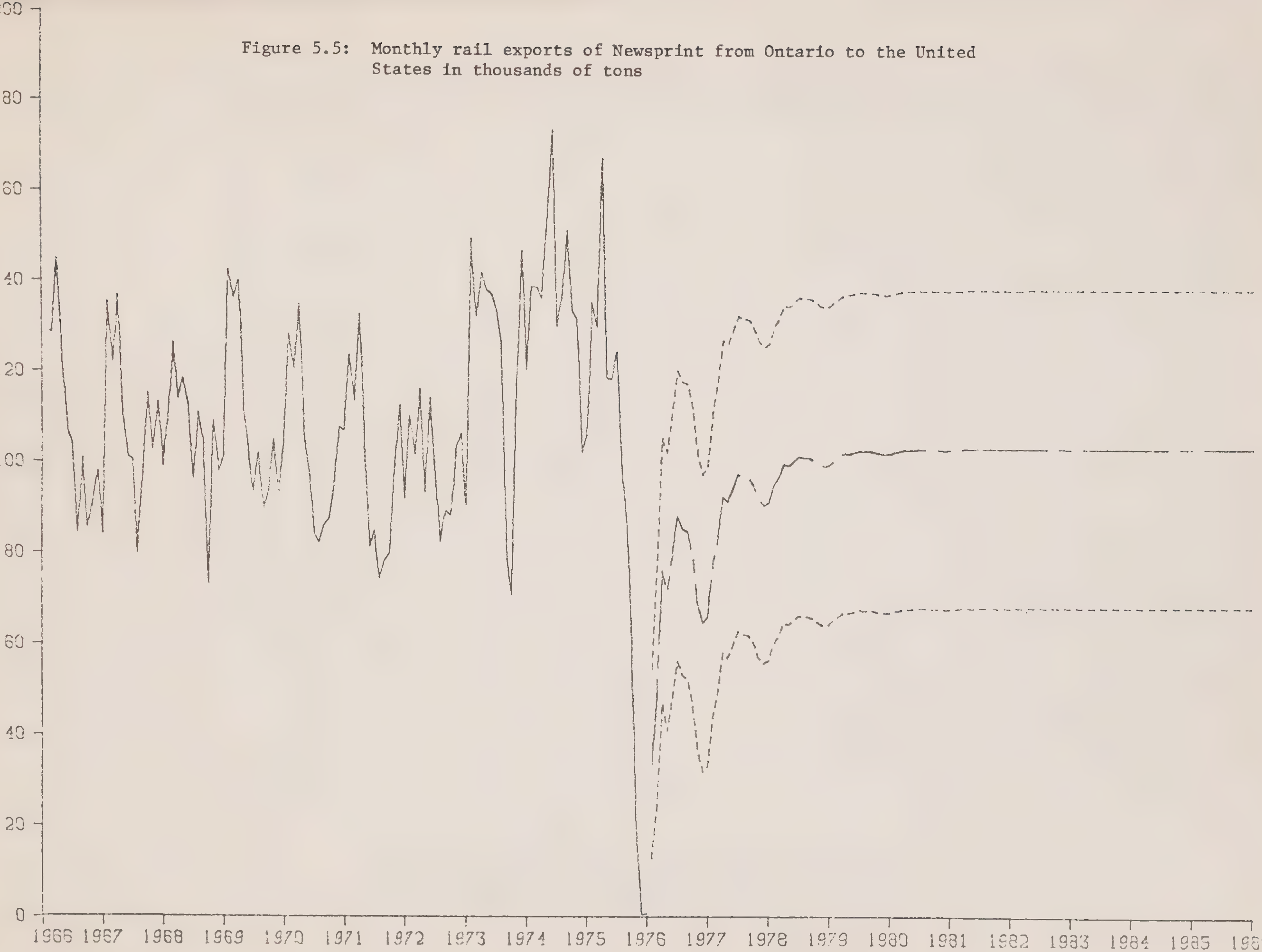
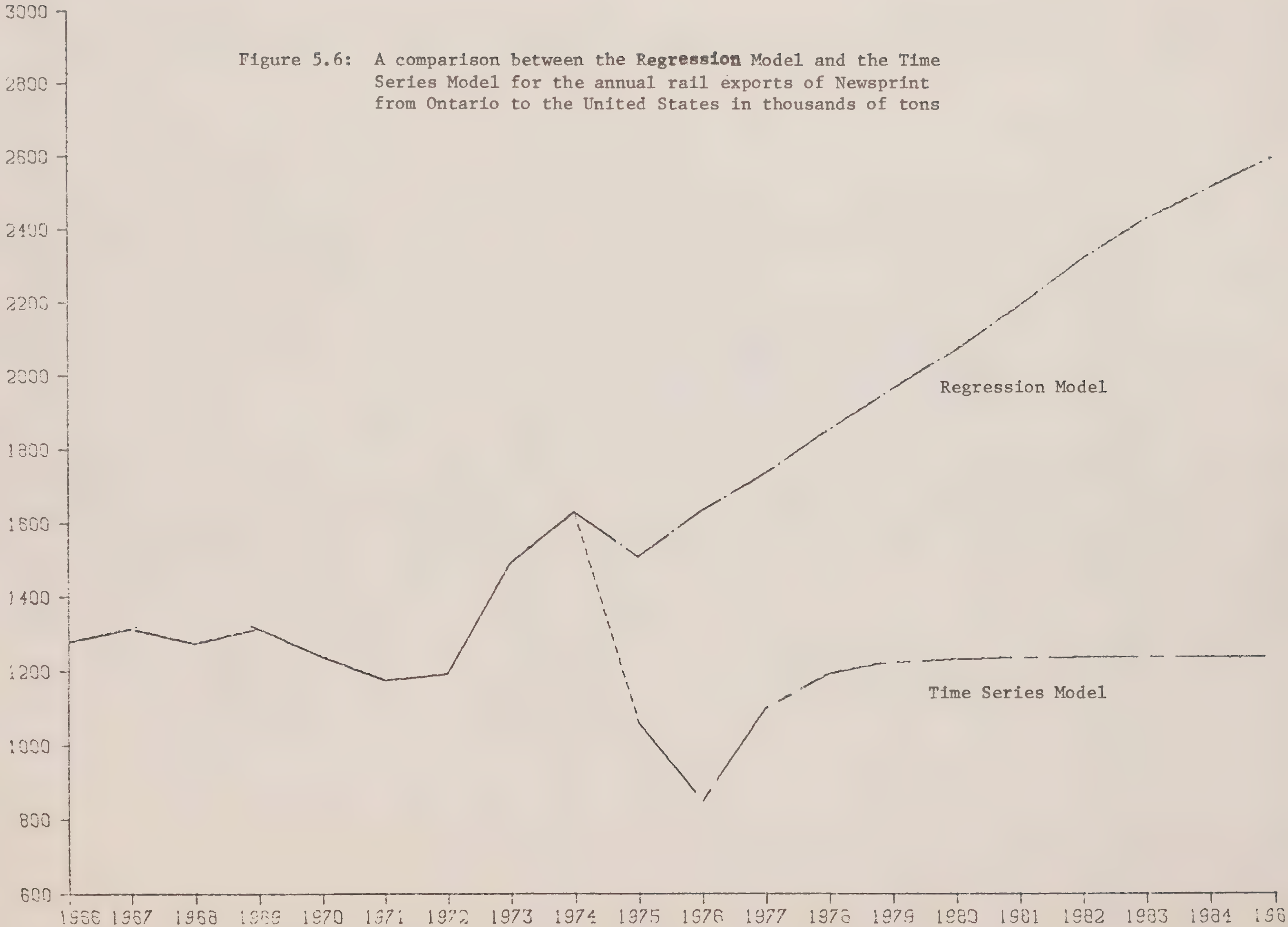


Figure 5.6: A comparison between the **Regression** Model and the Time Series Model for the annual rail exports of Newsprint from Ontario to the United States in thousands of tons



5.5 Marine Exports of Newsprint from the Atlantic Provinces to the United States.

Data on monthly marine exports of Newsprint from the Atlantic Provinces to the United States from January 1966 to December 1975 in thousands of tons appear in Figure 5.7. The observed marine flows are comparable in volume to that of the rail shipments from the Atlantic Provinces to the United States but slower transit times and problems of stevedoring have not encouraged increased usage of water transport. Instead a switch towards the rail mode is apparent and marine movements have declined from over 700,000 tons in 1966 down to less than 350,000 tons by 1975. If Z_t represents the movement during month t in millions of tons, then Z_t may be described by a moving average time series model

$$W_t = (1 - \underset{(\pm 0.082)}{0.889}\, B)a_t$$

where $W_t = \nabla Z_t$ and the residual standard error is estimated to be 0.0141. Diagnostic checks applied to the residuals indicate marginally significant values of the autocorrelation function at lags 10 and 25 but otherwise the model is judged adequate.

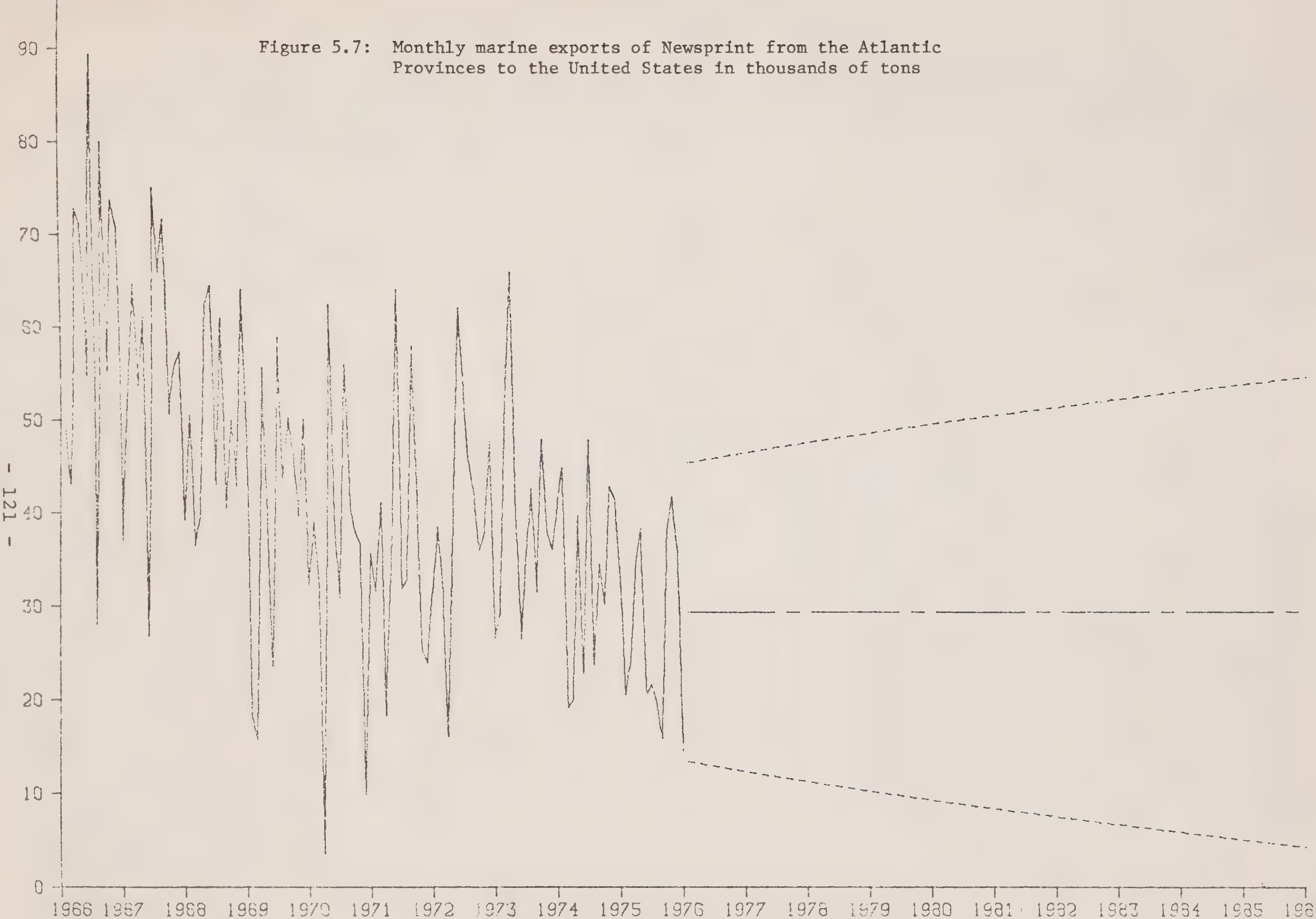
The model suggests that the data is homogeneous non-stationary and without trend: monthly forecasts to December 1985 using this model also appear in Figure 5.7 together with their 75% confidence limits. Although there is an apparent downward trend prior to 1976, the model does not confirm this but instead suggests that the series is non-stationary and as a consequence forecasts a constant level of movement to 1985. However, it is possible that modal substitution of marine by rail may be levelling off.

The data and forecasts on an annual basis are given in Table 5.4 and are compared with data and forecasts from the earlier regression model in Figure 5.8. Newsprint production in the United States is one of the explanatory variables used in the regression and its projected increase has resulted in the decline of the forecasts of marine flows to 174,000 tons by 1985. In the longer term, the time series approach suggests a stable level of traffic which might be more realistic than the forecasts suggested by the earlier regression analysis.

Table 5.4: Annual marine exports of Newsprint from the Atlantic Provinces to the United States in thousands of tons: the forecasts were obtained from the time series model

Year	Data	Year	Forecasts
1966	725	1978	350
67	675	79	350
68	603	80	350
69	475	81	350
70	423	82	350
71	434	83	350
72	476	84	350
73	488	85	350
74	400		
75	326		

Figure 5.7: Monthly marine exports of Newsprint from the Atlantic Provinces to the United States in thousands of tons



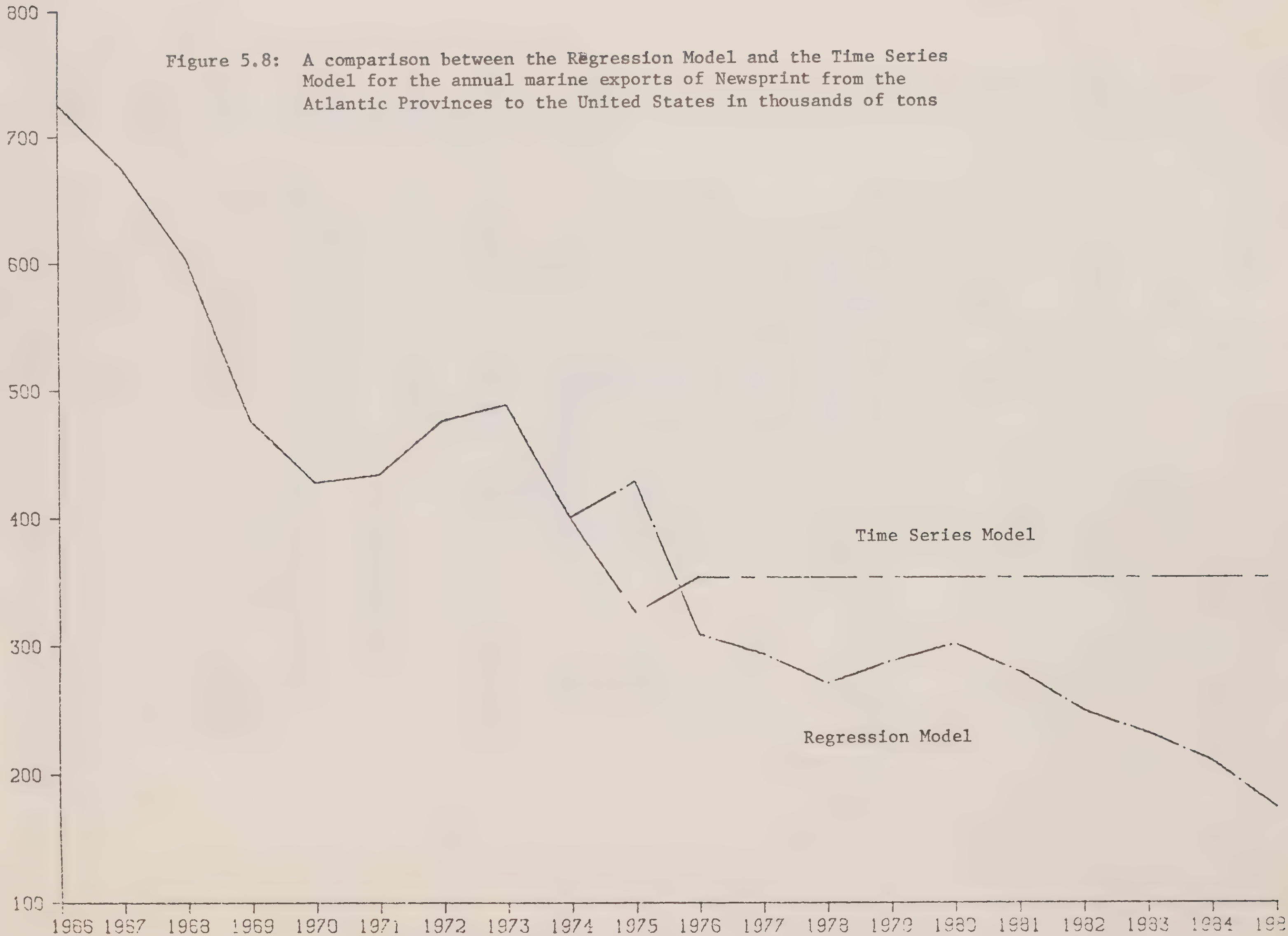


Figure 5.8: A comparison between the Regression Model and the Time Series Model for the annual marine exports of Newsprint from the Atlantic Provinces to the United States in thousands of tons

5.6 Marine Exports of Newsprint from Quebec to the United States

Data on monthly marine exports of Newsprint from Quebec to the United States from January 1966 to December 1975 in thousands of tons appear in Figure 5.9. In 1966 the marine mode accounted for 30% of Newsprint from Quebec to the United States while in 1975 this was down to 15%. The downward trend in the observed marine series is thought to represent the increasing preference for the rail mode on the part of the shippers rather than any consistent decrease in overall demand. If Z_t represents the movement during month t in millions of tons then Z_t may be described by a mixed autoregressive - moving average seasonal time series model

$$\underset{(\pm 0.105)}{(1 - 0.741}\ B^{12})\tilde{Z}_t = \underset{(\pm 0.205)}{(1 - 0.591}\ B^{12})a_t$$

$$\tilde{Z}_t = Z_t - \underset{(\pm 0.0077)}{0.0320}$$

and the residual standard error is estimated to be 0.0158. Diagnostic checks applied to the residuals indicate that the model is adequate.

The model suggests that the data is stationary and contains a seasonal component: monthly forecasts to December 1985 using this model also appear in Figure 5.9 together with their 75% confidence limits. The forecasts exhibit a damped seasonal pattern: shipments that are moved along the Seaway will contribute the most to this seasonality.

The data and forecasts on an annual basis are given in Table 5.5 and are compared with data and forecasts from the earlier regression model in Figure 5.10. As in the case of the flows from the Atlantic Provinces to the United States, the regression results exhibit a decreasing trend.

In the short run movements might fluctuate but in the longer run the volume of Newsprint freight moved by marine is expected to stay fairly constant as indicated by the time series analysis.

Table 5.5: Annual marine movements of Newsprint from Quebec to the United States in thousands of tons: forecasts were derived from the Time Series Model

Year	Data	Year	Forecasts
1966	778	1978	390
67	644	79	390
68	596	80	390
69	523	81	390
70	472	82	390
71	431	83	390
72	487	84	390
73	528	85	390
74	444		
75	353		

Figure 5.9: Monthly marine exports of Newsprint from Quebec to the United States in thousands of tons

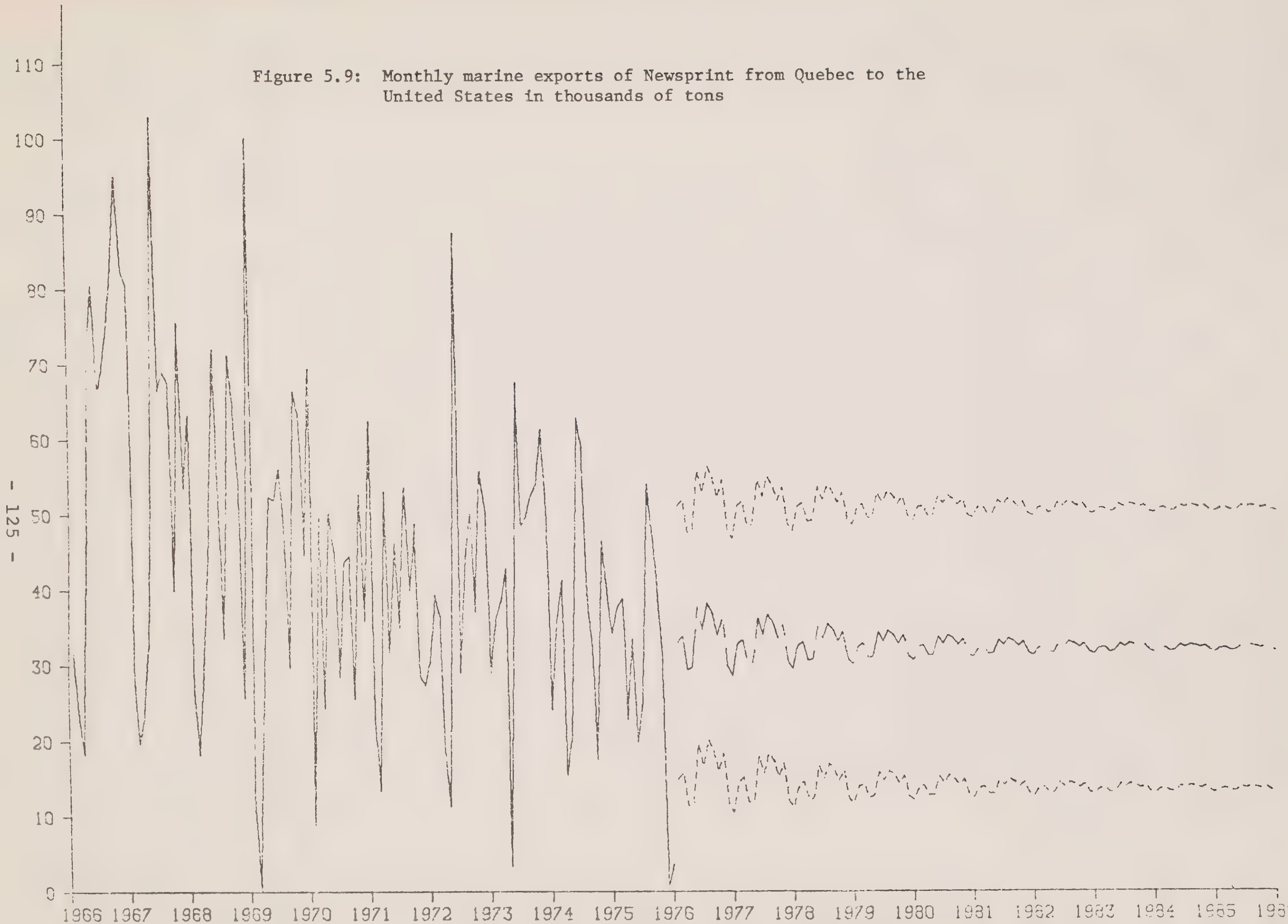
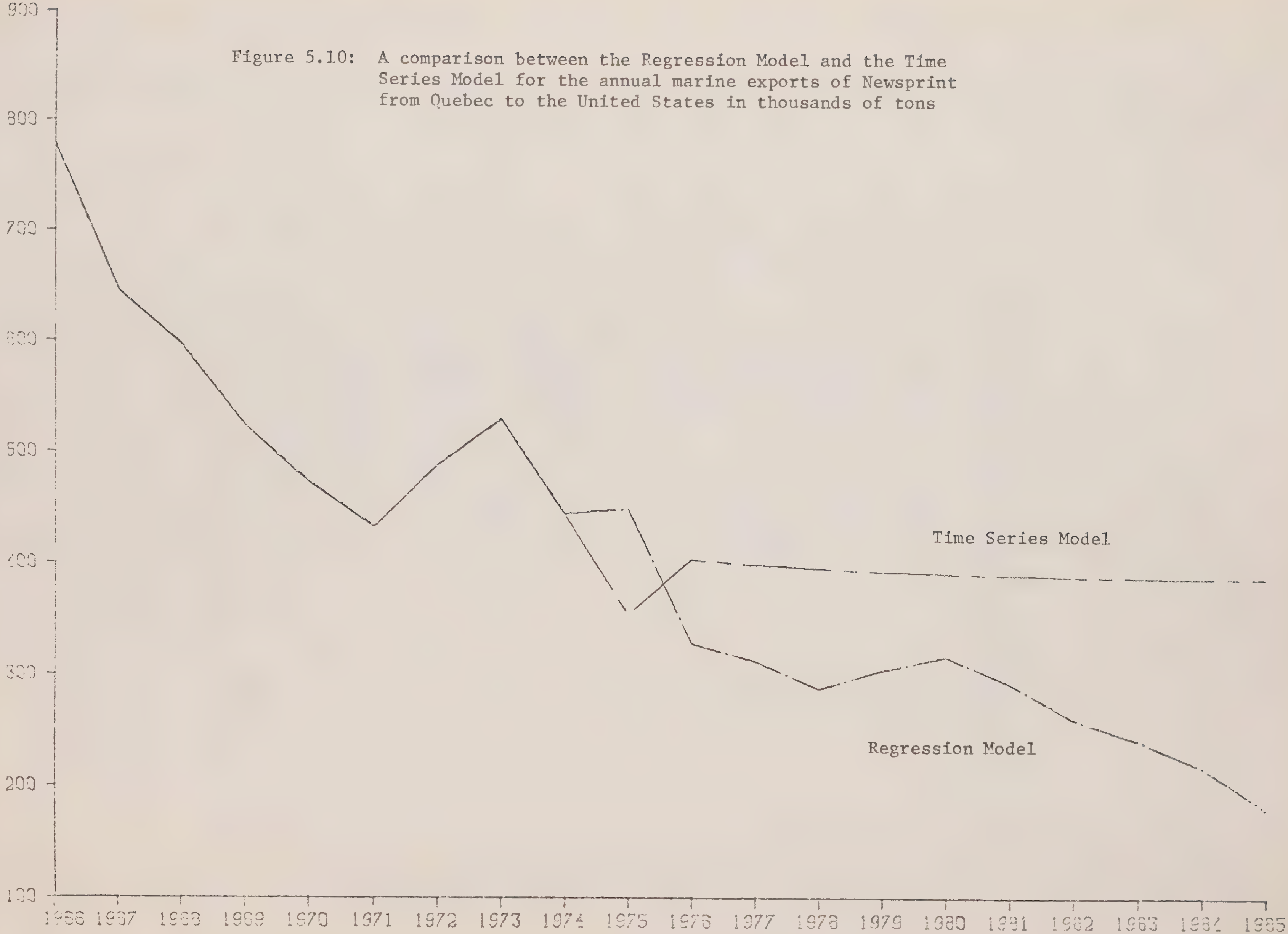


Figure 5.10: A comparison between the Regression Model and the Time Series Model for the annual marine exports of Newsprint from Quebec to the United States in thousands of tons



5.7 Marine Exports of Newsprint from Ontario to the United States

Data on monthly marine exports of Newsprint from Ontario to the United States from January 1966 to December 1975 in thousands of tons appear in Figure 5.11. Marine shipments have declined rather drastically from 351,000 tons in 1966 to 30,000 tons in 1975. This decrease is attributable mainly to modal substitution by rail: rail cars containing Newsprint are ferried across Lake Superior from Thunder Bay to the United States ports but such movements are considered part of the rail mode. If Z_t represents the movement during month t in millions of tons, Z_t may be described by the multiplicative seasonal time series model

$$\underset{(\pm 0.168)}{(1 - 0.579}\ B)W_t = \underset{(\pm 0.198)}{(1 - 0.418}\ B^{12})a_t$$

where $W_t = \nabla_{12} Z_t$ and the residual standard error is estimated to be 0.00929. Diagnostic checks applied to the residuals indicate a significant value of the autocorrelation function at lag 11 but otherwise the model is adequate.

The model suggests that the data is homogeneous non-stationary with a seasonal component: monthly forecasts to December 1985 using the model also appear in Figure 5.11 together with their 75% confidence limits. Since marine flows of Newsprint from Ontario to the United States occur mostly across the Great Lakes which are closed to navigation in Winter, there is a pronounced seasonal pattern and this is reproduced in the forecasts. The time series model does not predict a continued decrease in the marine movements, rather they are projected to remain at a constant level of about 60,000 tons per annum.

The data and forecasts on an annual basis are given in Table 5.6 and are compared with data and forecasts from the

earlier regression model in Figure 5.12. Unlike the time series results, the regression model forecasts a recovery of flows back to about 390,000 tons by 1985. Unless there is a switch back to marine from rail and unless demand increases sufficiently, this rather optimistic trend might not be realized.

Table 5.6: Annual marine exports of Newsprint from Ontario to the United States in thousands of tons: the forecasts were deived from the Time Series Model

Year	Data	Year	Forecasts
1966	351	1978	60
67	277	79	60
68	274	80	60
69	365	81	60
70	332	82	60
71	296	83	60
72	277	84	60
73	165	85	60
74	68		
75	30		

Figure 5.11: Monthly marine exports of Newsprint from Ontario to the United States in thousands of tons

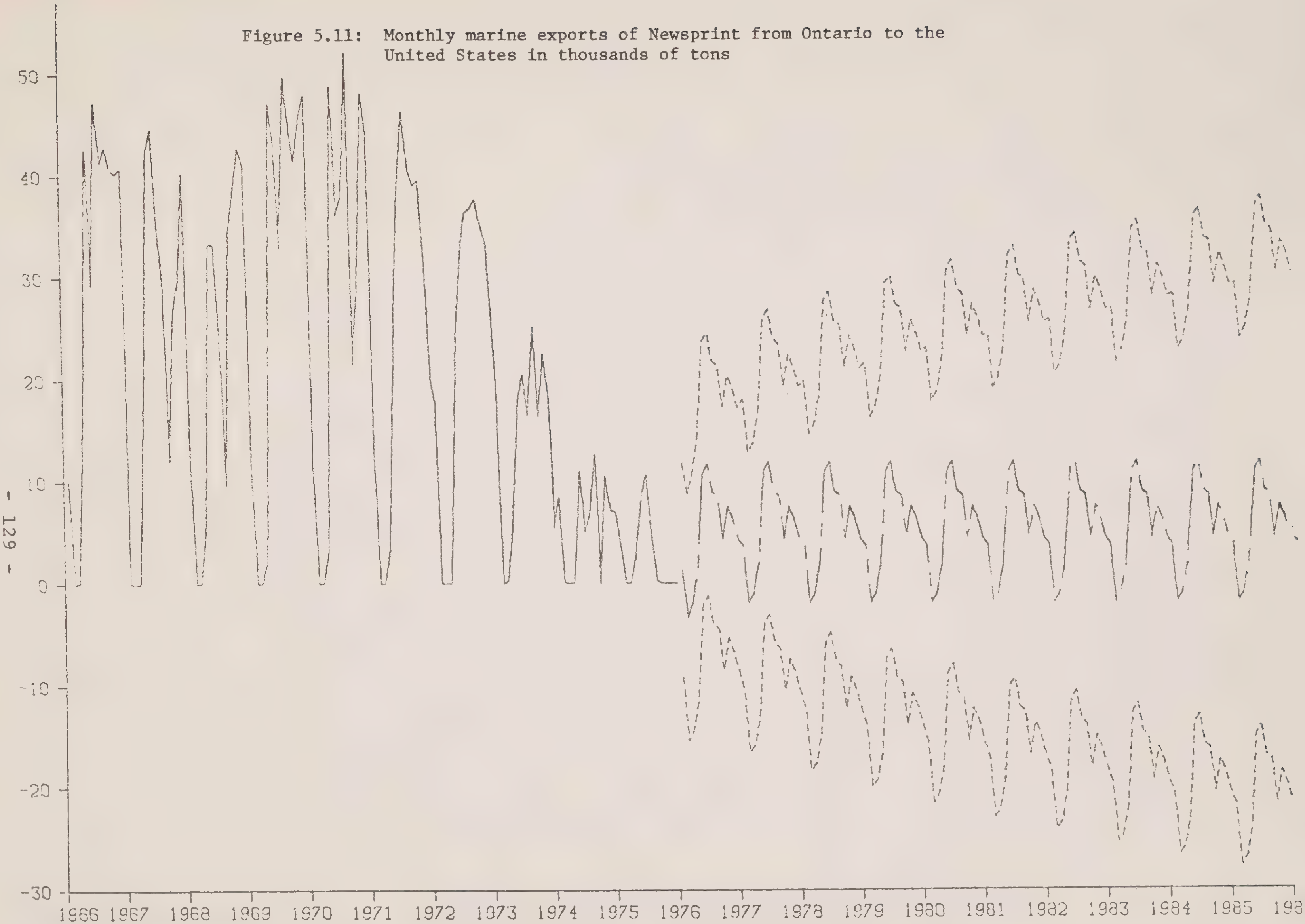
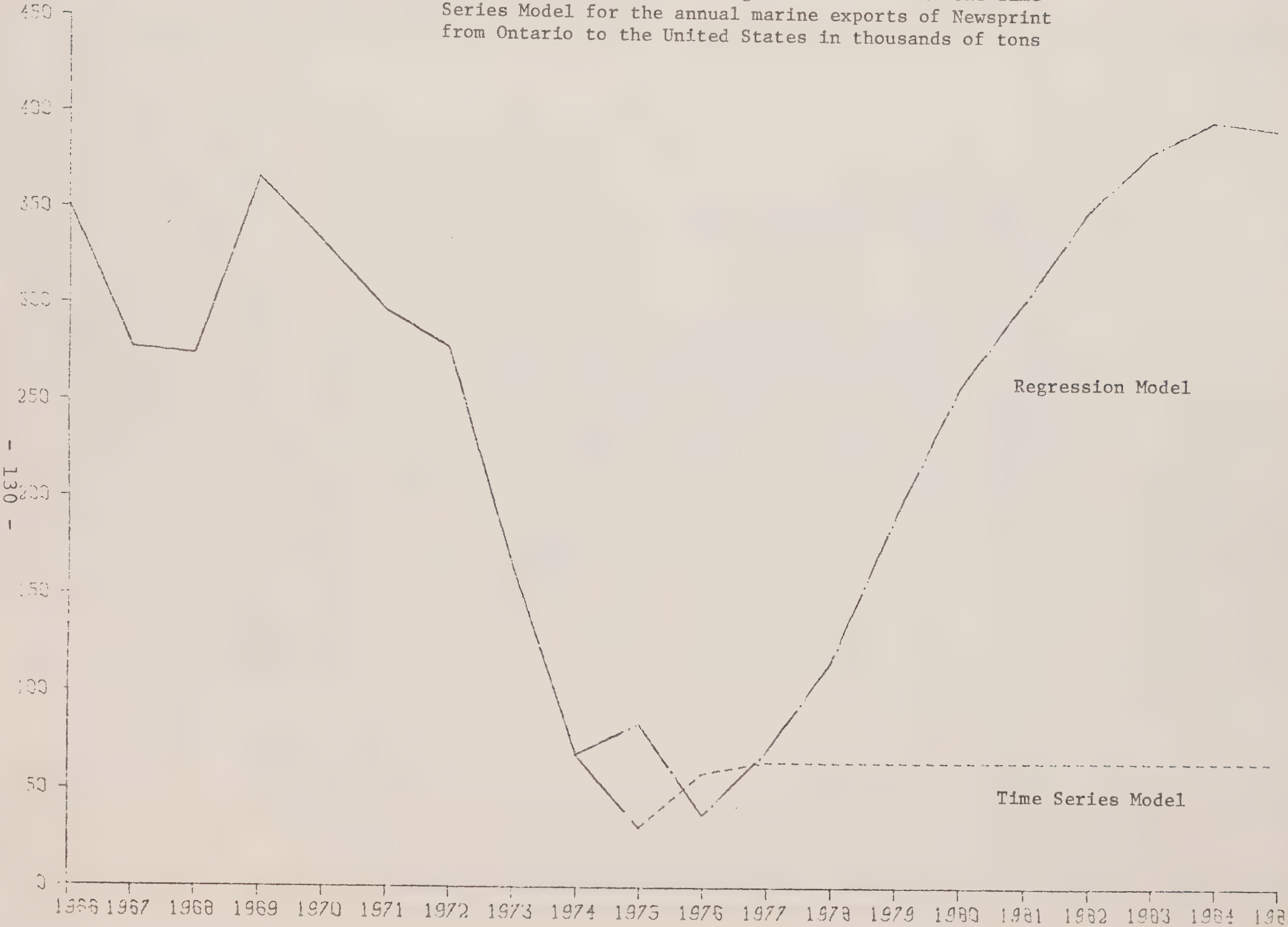


Figure 5.12: A comparison between the Regression Model and the Time Series Model for the annual marine exports of Newsprint from Ontario to the United States in thousands of tons



5.8 Marine Exports of Newsprint from British Columbia to the United States

Data on monthly marine exports of Newsprint from British Columbia to the United States from January 1966 to December 1975 in thousands of tons, appear in Figure 5.13. The observed series is characterised by considerable variation with no pronounced trends. If Z_t represents the movement during month t in millions of tons, then Z_t may be described by a multiplicative seasonal time series model

$$\underset{(\pm 0.179)}{(1 - 0.263\ B)}\tilde{Z}_t = \underset{(\pm 0.198)}{(1 + 0.237\ B^{12})}a_t$$

$$\tilde{Z}_t = Z_t - \underset{(\pm 0.0049)}{0.0546}$$

and the residual standard error is estimated to be 0.0162. Diagnostic checks applied to the residuals indicate that the model is adequate.

The model suggests that the data is stationary with a secondary seasonal component: monthly forecasts to December 1985 using this model also appear in Figure 5.13 together with their 75% confidence limits. Apart from a twelve month adjustment period, the forecasts are constant to 1985.

The data and forecasts on an annual basis are given in Table 5.7 and are compared with data and forecasts from the earlier regression model in Figure 5.14. In contrast to the time series model, the regression model predicts a drop to 500,000 tons in 1976 and then an upward trend reaching 650,000 tons by 1981 and 715,000 tons by 1985. Increasing Newsprint production in B.C. after 1976 accounts for the growth but the negative influence of rising Newsprint production in the United States can be seen in the later part of the forecast period.

Table 5.7: Annual marine exports of Newsprint from British Columbia to the United States in thousands of tons: forecasts were derived from the Time Series Model

Year	Data	Year	Forecasts
1966	867	1978	650
67	744	79	650
68	630	80	650
69	662	81	650
70	602	82	650
71	551	83	650
72	555	84	650
73	729	85	650
74	673		
75	528		

Figure 5.13: Monthly marine exports of Newsprint from British Columbia to the United States in thousands of tons

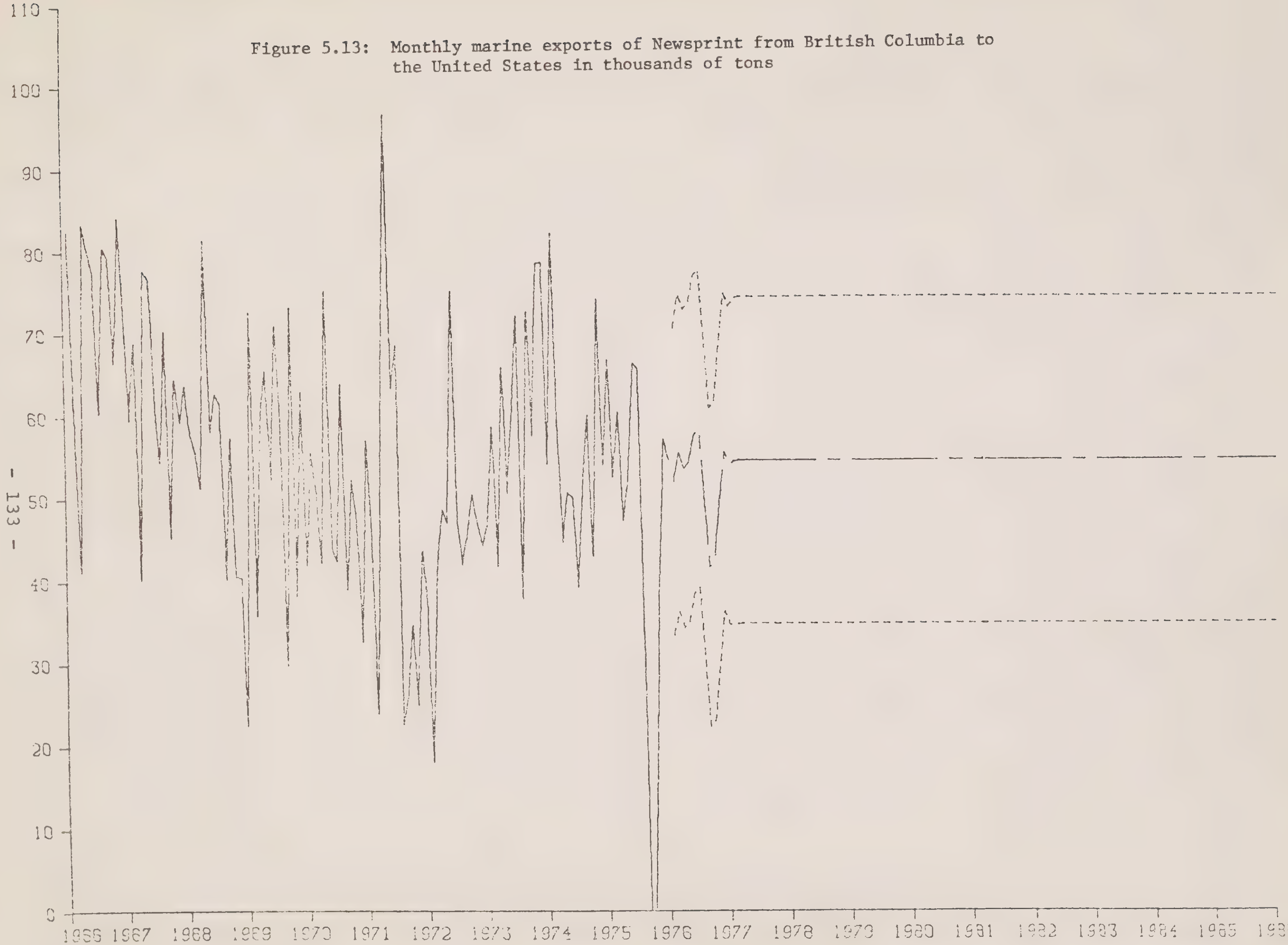
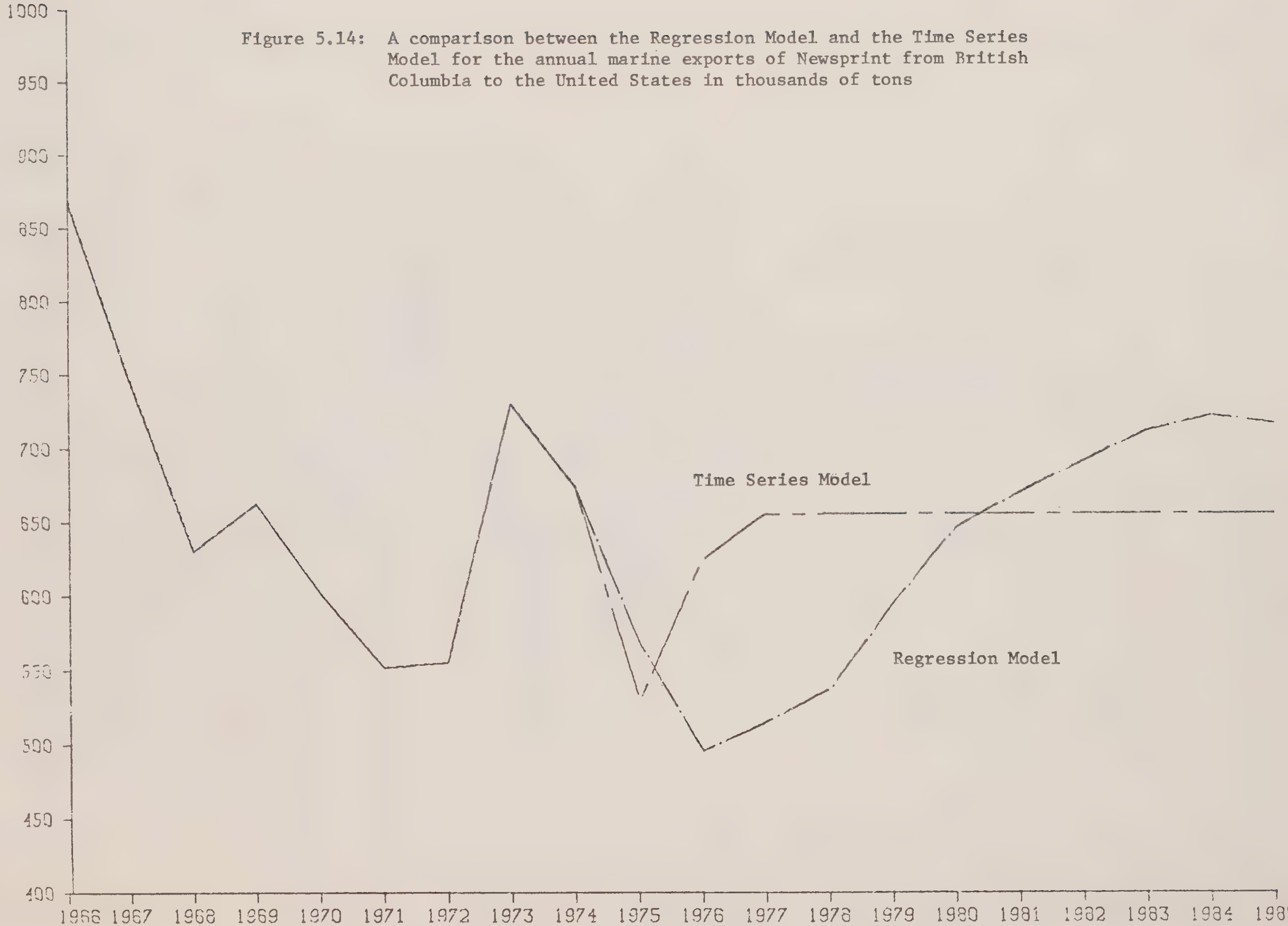


Figure 5.14: A comparison between the Regression Model and the Time Series Model for the annual marine exports of Newsprint from British Columbia to the United States in thousands of tons



5.9 Marine Exports of Newsprint from the Atlantic Provinces to Western Europe

Data on monthly marine exports of Newsprint from the Atlantic Provinces to Western Europe from January 1966 to December 1975 in thousands of tons appear in Figure 5.15. The observed series is characterised by considerable variation with no pronounced trends. If Z_t represents the movement during month t in millions of tons, then Z_t may be described by a time series model

$$\tilde{Z}_t = Z_t - \underset{(\pm 0.0017)}{0.0205} = a_t$$

and the residual standard error is estimated to be 0.0095. The series appears as random fluctuations about a constant level and no autoregressive or moving average parameters are significant. As a result monthly forecasts are constant and appear in Figure 5.15 together with their 75% confidence limits. Annual shipments of about 250,000 tons are projected from 1976 to 1985.

The data and forecasts on an annual basis are given in Table 5.8 and are compared with data and forecasts from the earlier regression model in Figure 5.16. In the regression model, increasing Newsprint consumption in Western Europe accounts for the predicted growth of the flows to about 410,000 tons by 1985 although competition from Scandinavia for the Western European Market may not have been adequately considered. As a result the time series forecasts are considered more reliable.

Table 5.8: Annual marine exports of Newsprint from the Atlantic Provinces to Western Europe in thousands of tons: forecasts were derived from the Time Series Model

Year	Data	Year	Forecasts
1966	195	1978	250
67	175	79	250
68	224	80	250
69	288	81	250
70	249	82	250
71	240	83	250
72	306	84	250
73	283	85	250
74	281		
75	224		

Figure 5.15: Monthly marine exports of Newsprint from the Atlantic Provinces to Western Europe in thousands of tons

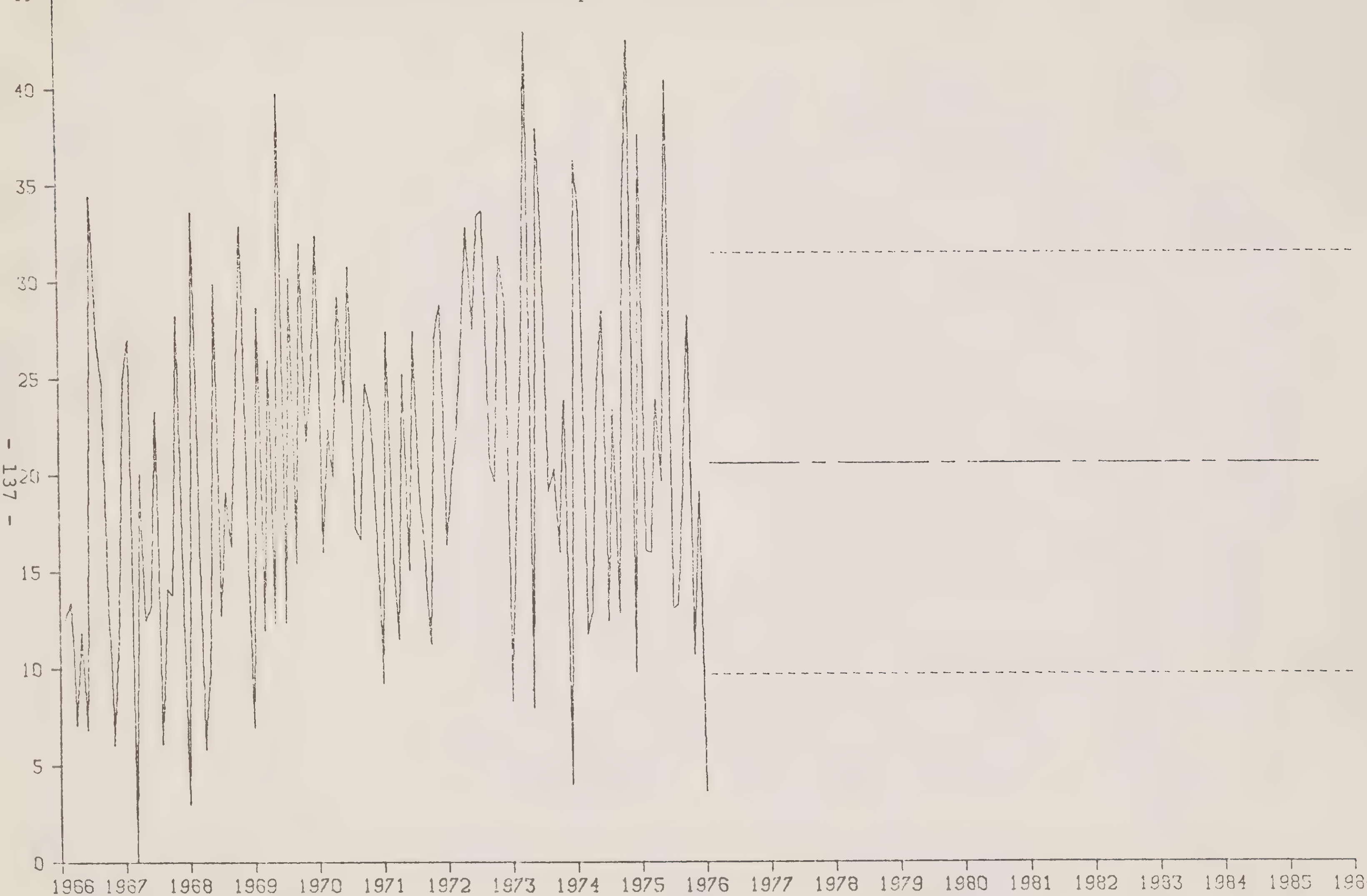
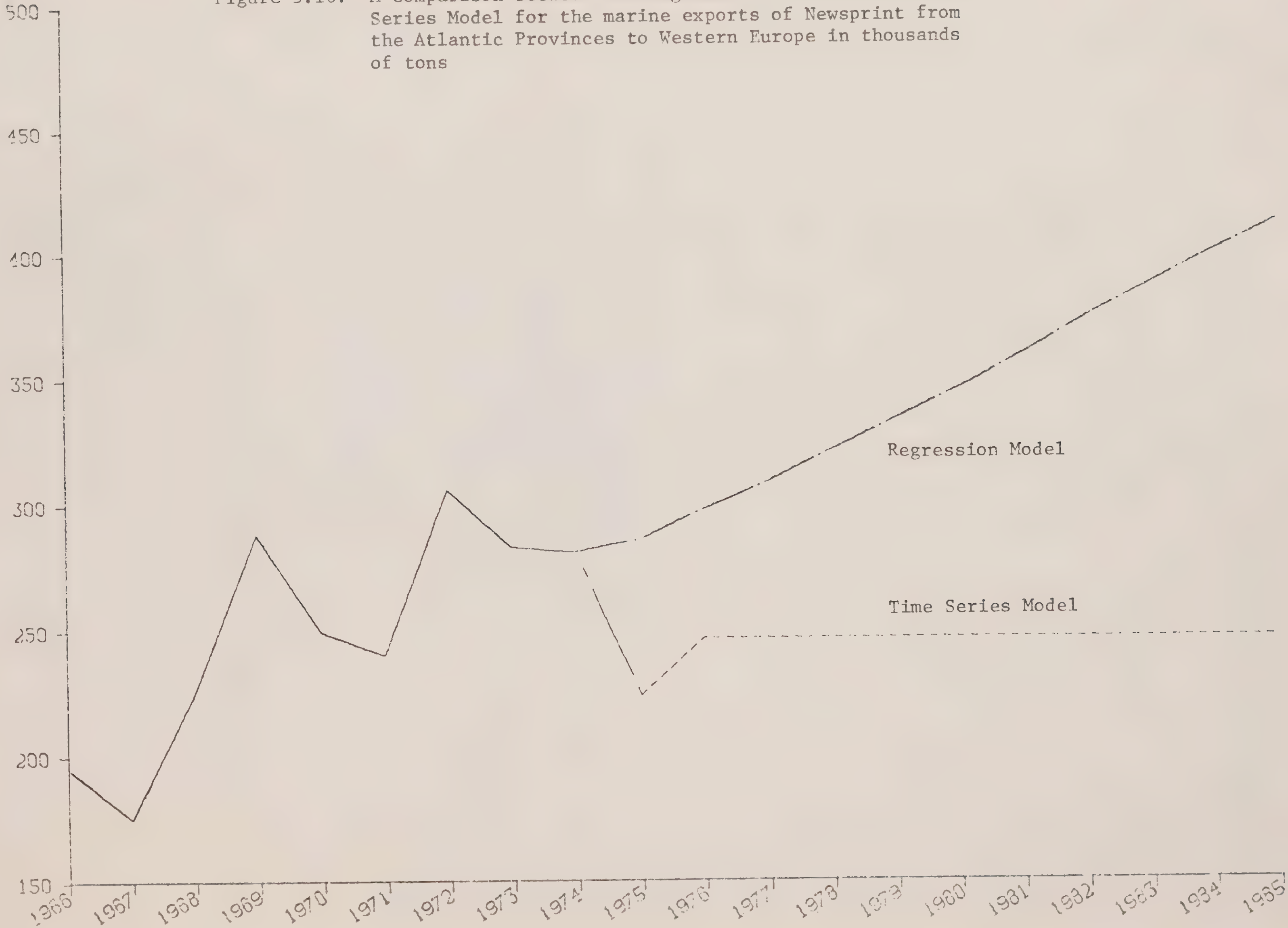


Figure 5.16: A comparison between the Regression Model and the Time Series Model for the marine exports of Newsprint from the Atlantic Provinces to Western Europe in thousands of tons



5.10 Marine Exports of Newsprint from Quebec to Western Europe

Data on monthly marine exports of Newsprint from Quebec to Western Europe from January 1966 to December 1975 in thousands of tons appear in Figure 5.17. Notice the erratic movements during 1974. If Z_t represents the movement during month t in millions of tons then Z_t may be described by a time series model

$$\tilde{Z}_t = Z_t - \underset{(\pm 0.0016)}{0.0244} = a_t$$

and the residual standard error is estimated to be 0.0090. Diagnostic checks applied to the residuals indicate a marginally significant value of the global χ^2 statistic but no recognisable patterns in the autocorrelation function. The series appears as random fluctuations about a constant level and no autoregressive or moving average parameters are significant. As a result monthly forecasts are constant and appear in Figure 5.17 together with their 75% confidence limits.

The data and forecasts on an annual basis are given in Table 5.9 and are compared with data and forecasts from the earlier regression model in Figure 5.18. As in the case of the export of Newsprint from the Atlantic Provinces to Western Europe, the regression model may not have adequately accounted for competition from Scandinavia for the Western European Market and therefore the projected growth indicated by the regression model may not be realised.

Table 5.9: Annual marine exports of Newsprint from Quebec to Western Europe in thousands of tons: forecasts were derived from the Time Series Model

Year	Data	Year	Forecasts
1966	278	1978	290
67	241	79	290
68	273	80	290
69	282	81	290
70	329	82	290
71	271	83	290
72	325	84	290
73	286	85	290
74	349		
75	298		

Figure 5.17: Monthly marine exports of Newsprint from Quebec to Western Europe in thousands of tons

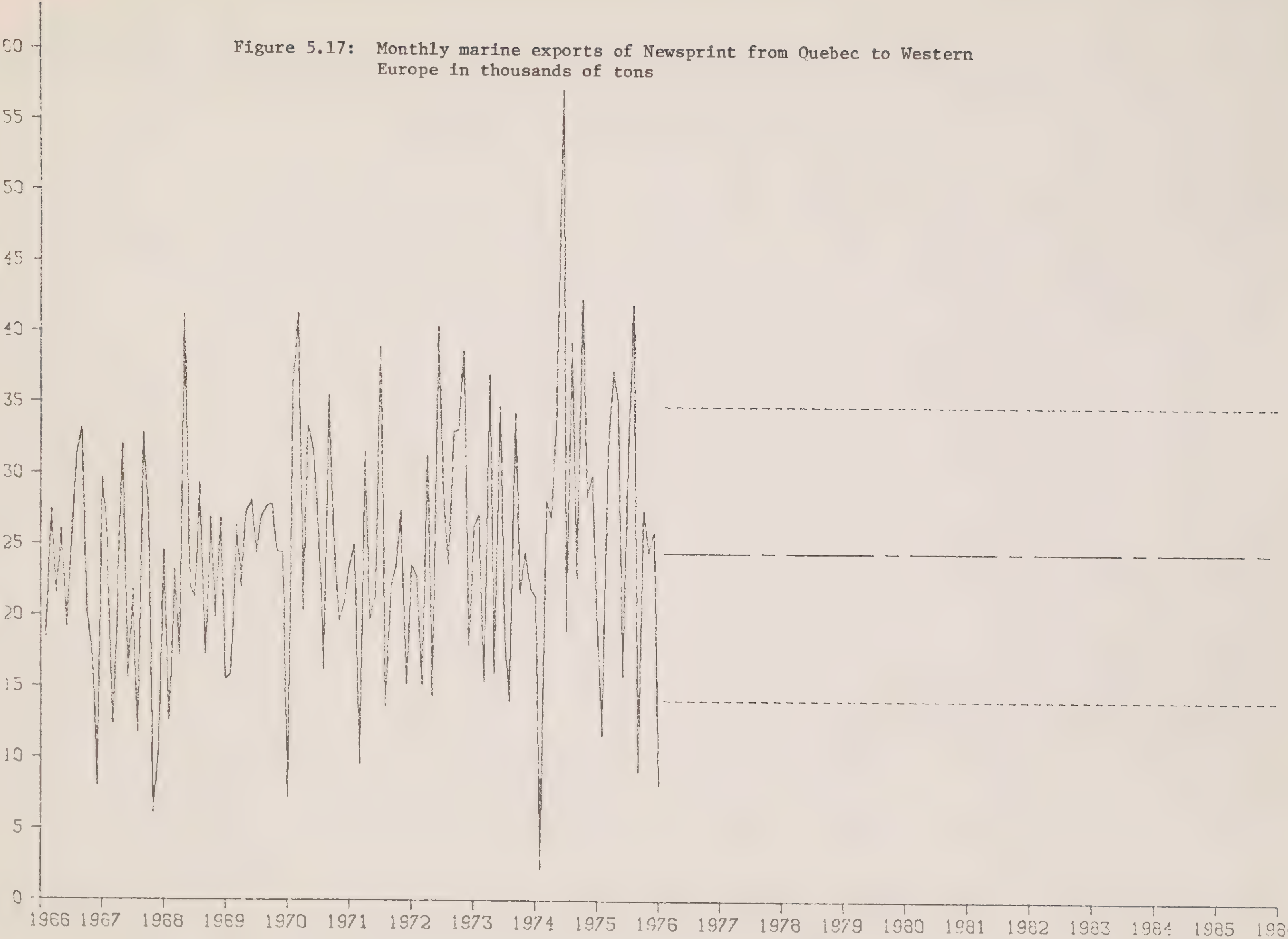
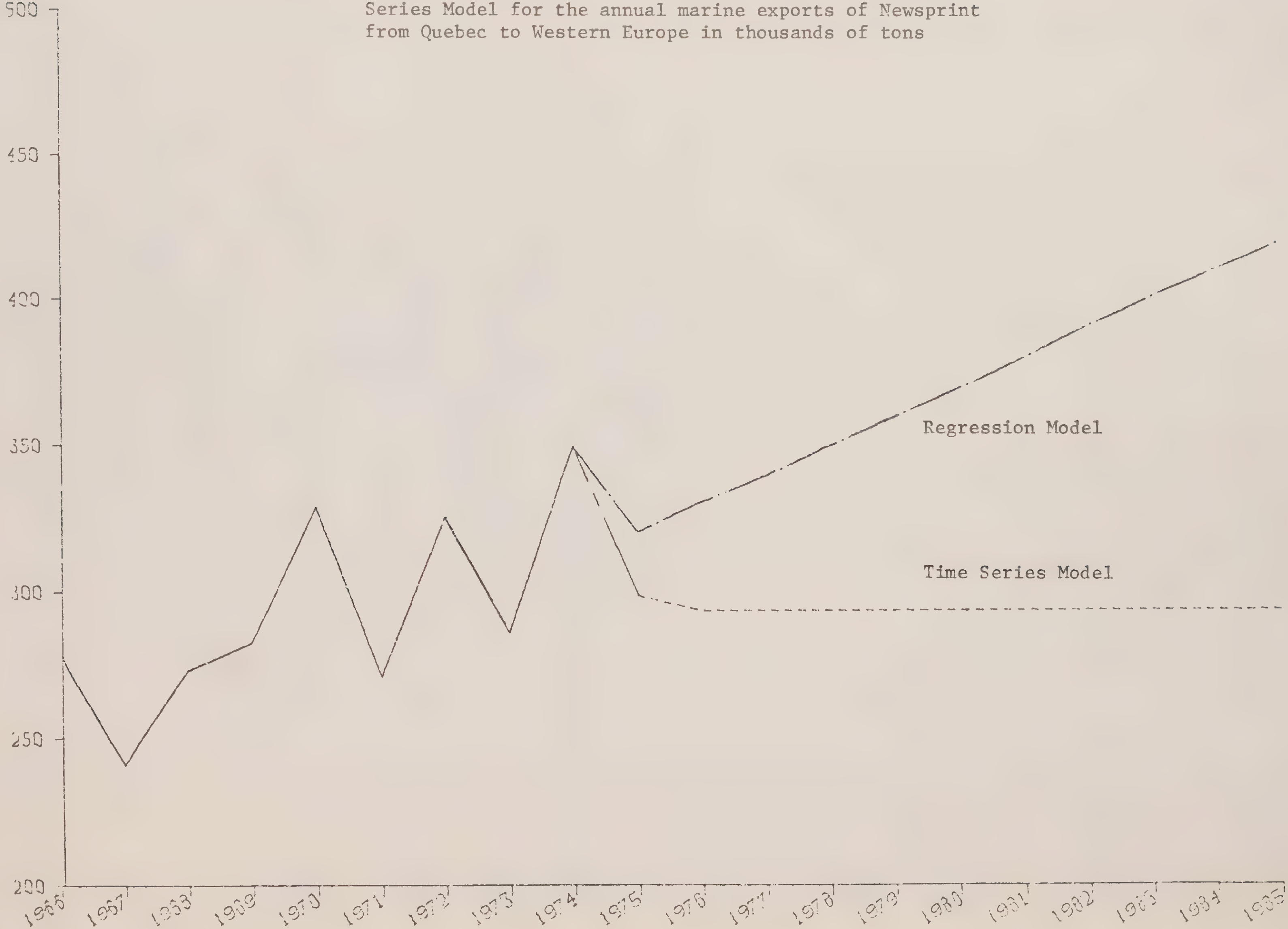


Figure 5.18: A comparison between the Regression Model and the Time Series Model for the annual marine exports of Newsprint from Quebec to Western Europe in thousands of tons



5.11 Marine Exports of Newsprint from the Atlantic Provinces to Latin America

Data on monthly marine exports of Newsprint from the Atlantic Provinces to Latin America from January 1966 to December 1975 in thousands of tons appear in Figure 5.19. The observed series suggests an overall growth in movements until 1970 and thereafter indicates fluctuations in movements about a constant level. If Z_t represents the movement during month t in millions of tons then Z_t may be described by a moving average time series model

$$W_t = (1 - \underset{(\pm 0.069)}{0.915}\, B)a_t$$

where $W_t = \nabla Z_t$ and the residual standard error is estimated to be 0.0071. Diagnostic checks applied to the residuals indicate that the model is adequate.

The model suggests that the data is homogeneous non-stationary and with no seasonal component: monthly forecasts to December 1985 are constant using this model and appear in Figure 5.19 together with their 75% confidence limits.

The data and forecasts on an annual basis are given in Table 5.10 and are compared with the data and forecasts from the earlier regression model in Figure 5.20. Based on sustained growth in Newsprint production in the Atlantic Provinces and in Newsprint consumption in Latin America the regression model predicts increasing export flows in the forecast period, reaching about 277,000 tons by 1985.

Table 5.10: Annual marine exports of Newsprint from the Atlantic Provinces to Latin America in thousands of tons: forecasts were derived from the Time Series Model

Year	Data	Year	Forecasts
1966	129	1978	230
67	120	79	230
68	118	80	230
69	180	81	230
70	222	82	230
71	192	83	230
72	252	84	230
73	208	85	230
74	241		
75	226		

Figure 5.19: Monthly marine exports of Newsprint from the Atlantic Provinces to Latin America in thousands of tons

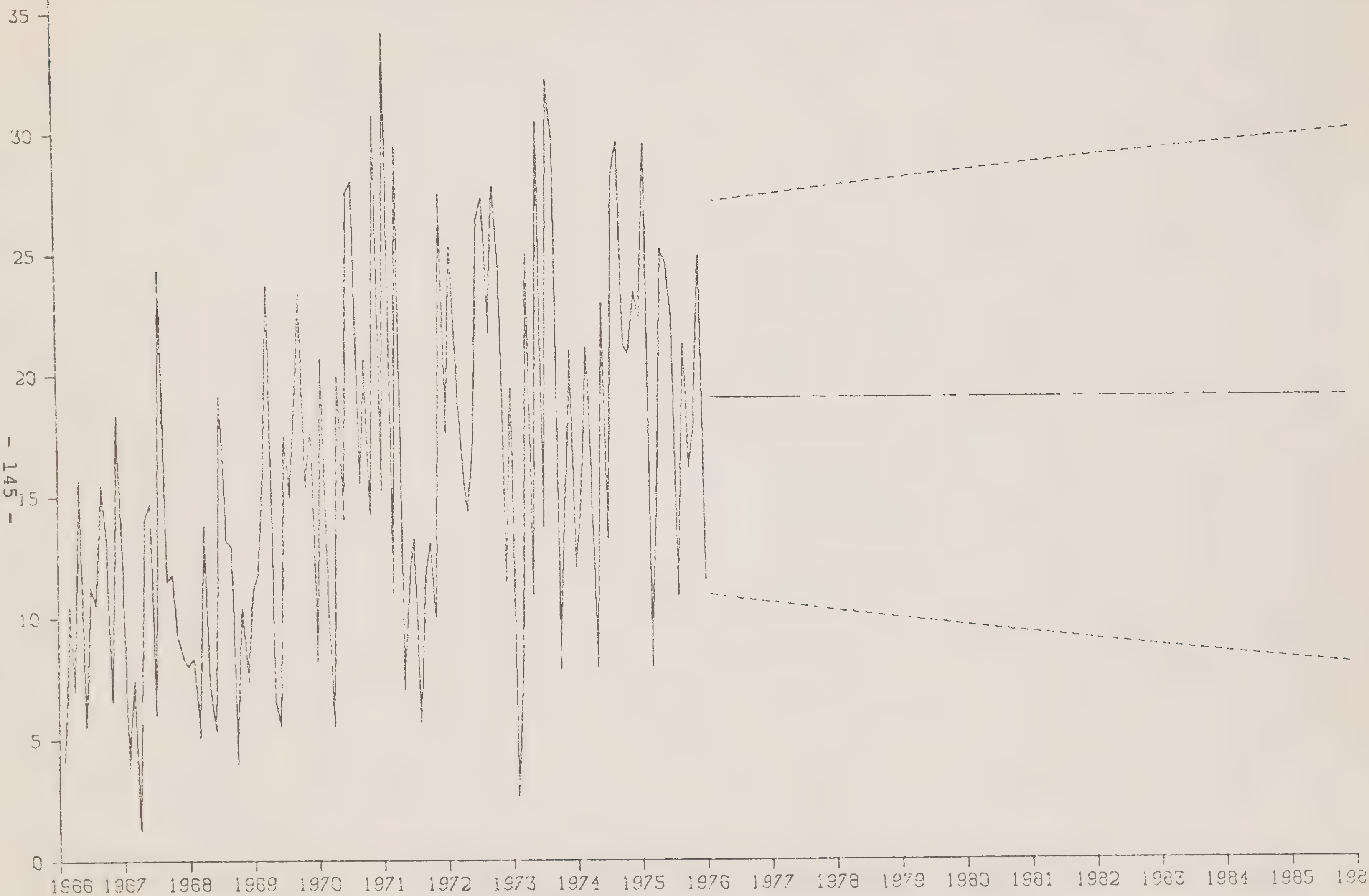
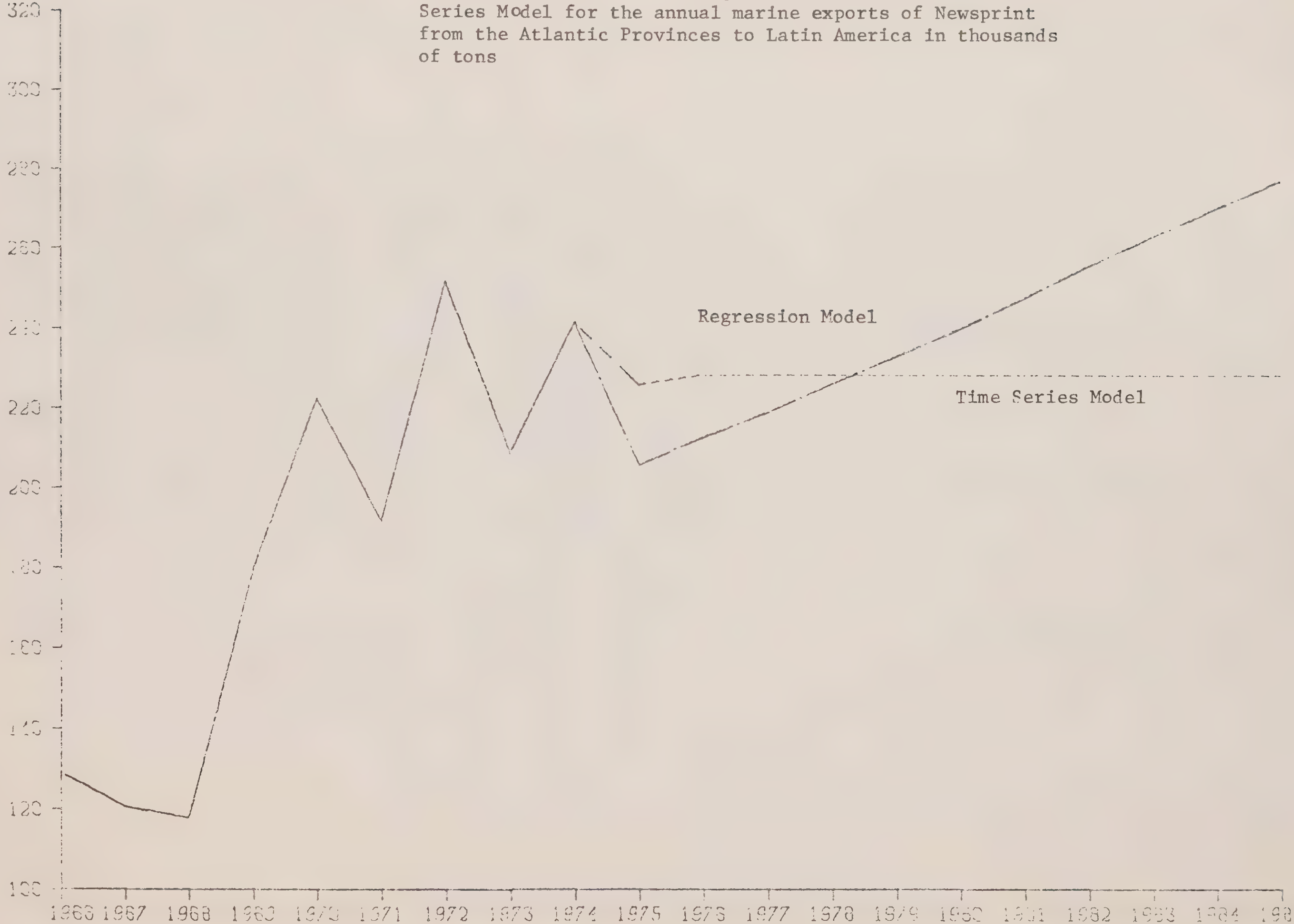


Figure 5.20: A comparison between the Regression Model and the Time Series Model for the annual marine exports of Newsprint from the Atlantic Provinces to Latin America in thousands of tons



5.12 Marine Exports of Newsprint from Quebec to Latin America

Data on monthly marine exports of Newsprint from Quebec to Latin America from January 1966 to December 1975 in thousands of tons appear in Figure 5.21. The observed series exhibits erratic behaviour with no pronounced trends. If Z_t represents the movement during month t in millions of tons then Z_t may be described by a mixed autoregressive - moving average seasonal time series model

$$\underset{(\pm 0.160)}{(1 - 0.758\, B^{12})}\tilde{Z}_t = \underset{(\pm 0.238)}{(1 - 0.670\, B^{12})}a_t$$

$$\tilde{Z}_t = Z_t - \underset{(\pm 0.0019)}{0.0167}$$

and the residual standard error is estimated to be 0.0058. Diagnostic checks applied to the residuals indicate a marginally significant value of the autocorrelation function at lag 2 but otherwise the model is considered satisfactory.

The model suggests that the data is stationary with a secondary seasonal component: monthly forecasts to December 1985 using this model also appear in Figure 5.21 together with their 75% confidence limits.

The data and forecasts on an annual basis are given in Table 5.11 and are compared with data and forecasts from the earlier regression model in Figure 5.22. Although both models show increased flows in the first year of forecast, the regression model forecasts continuing growth while the time series analysis predicts a levelling off in the flows. Anticipated increases in production and consumption are responsible for the growth in the regression model forecasts.

Table 5.11: Annual marine exports of Newsprint from Quebec to Latin America in thousands of tons: forecasts were derived from the Time Series Model

1966

Year	Data	Year	Forecasts
1966	185	1978	200
67	162	79	200
68	184	80	200
69	228	81	200
70	238	82	200
71	190	83	200
72	191	84	200
73	199	85	200
74	186		
75	179		

Figure 5.21: Monthly marine exports of Newsprint from Quebec to Latin America in thousands of tons

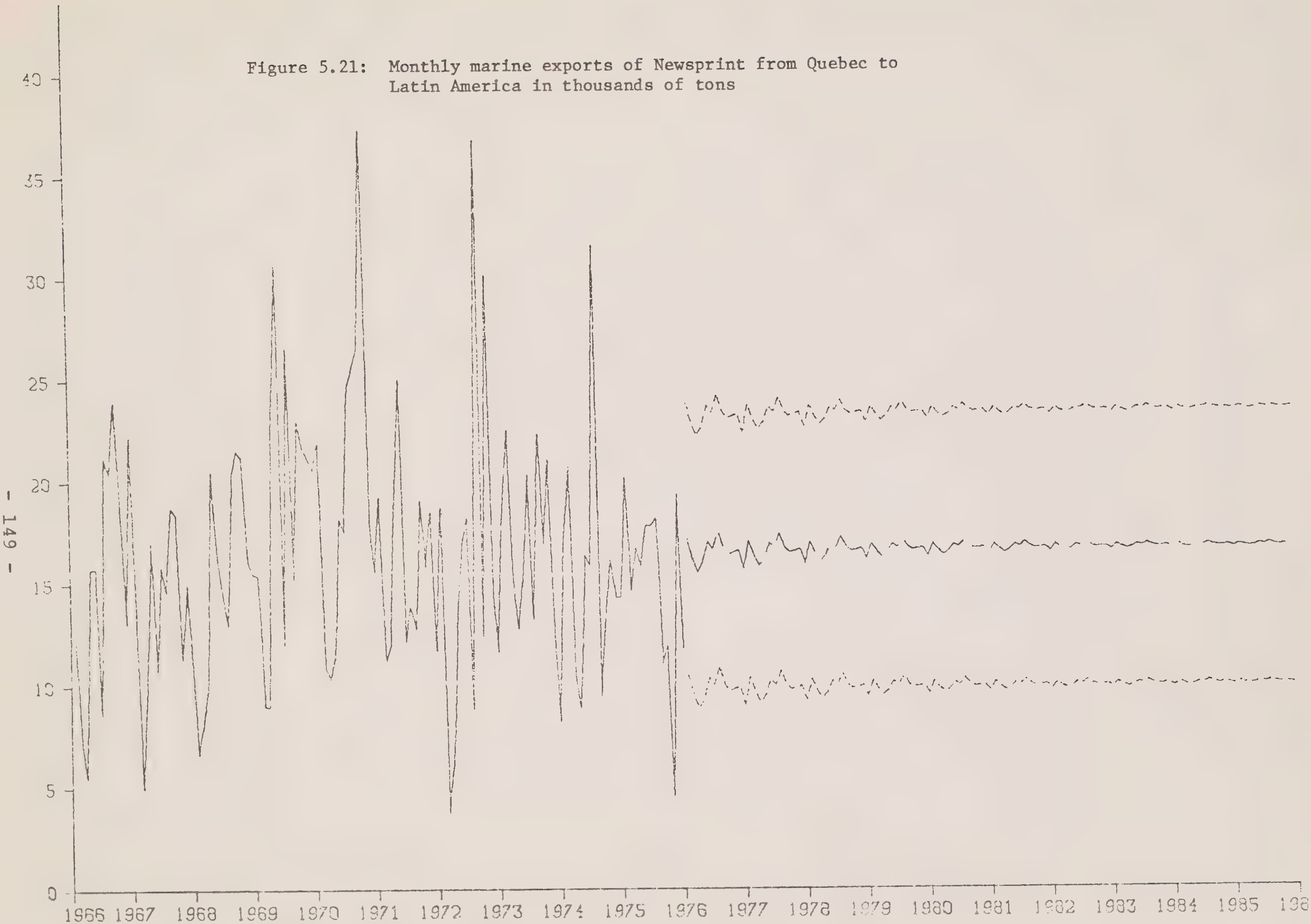
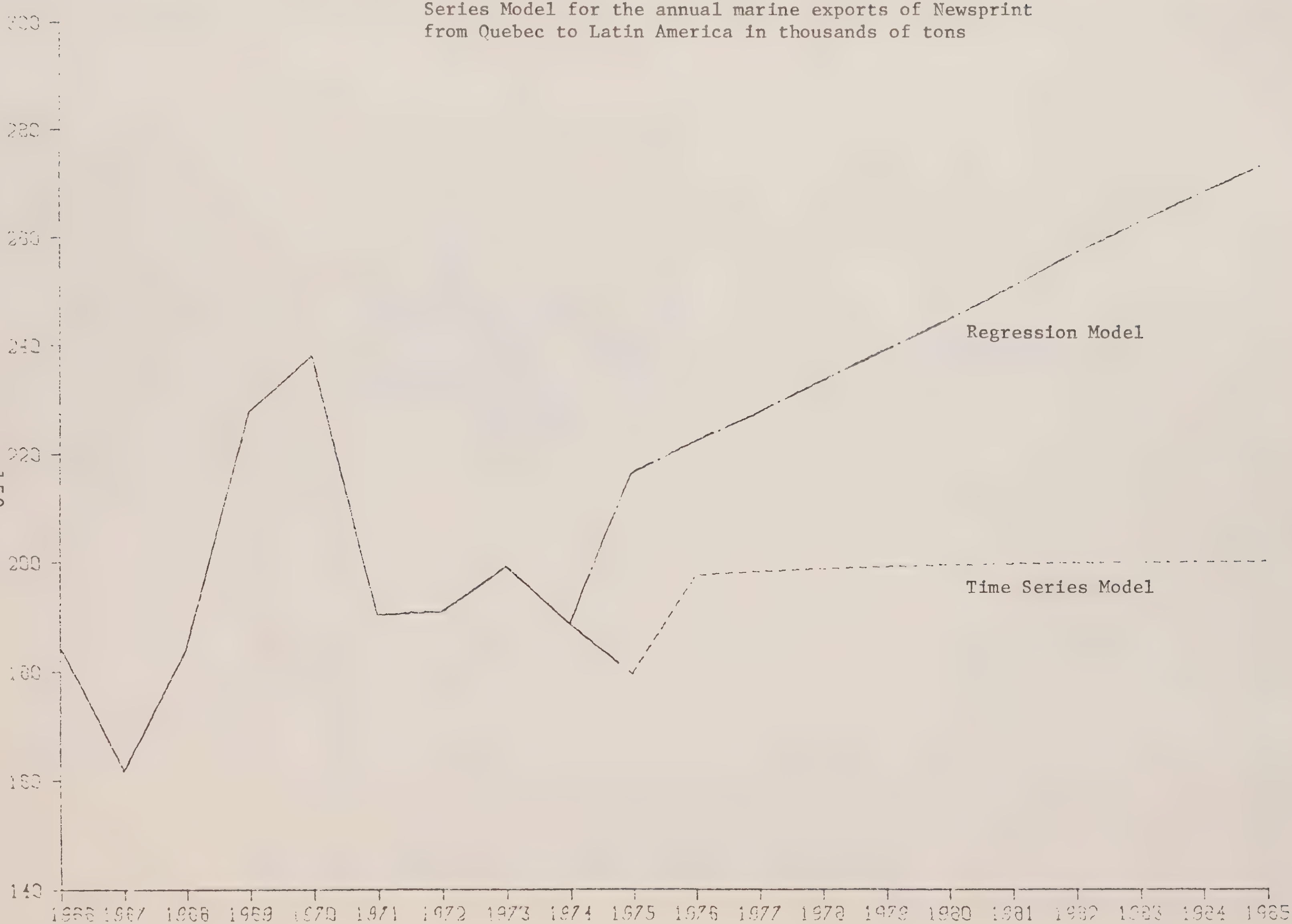


Figure 5.22: A comparison between the Regression Model and the Time Series Model for the annual marine exports of Newsprint from Quebec to Latin America in thousands of tons



Chapter 6

The Transportation of Chemicals

6.1 Analysis

Under the commodity grouping "Chemicals" we include both inorganic and organic compounds used as industrial raw materials and finished products such as pharmaceuticals and medicines, soaps and detergents, paints and varnishes. However we specifically exclude potash, fertilizers and agricultural chemicals, salt and sulphur. It should be noted at the outset that many of the statistics quoted in this section should be considered estimates only since the heterogeneous nature of the grouping has hindered detailed data analysis.

Since 1972 Canadian production of Chemicals has averaged 6.5 million tons per year, representing, at most, 2% of total world output: by contrast, the U.S. is estimated to account for 30% of world production. Regionally, Ontario, with its diversified industrial base, produces almost half of the Canadian Chemicals output by weight: the Prairie Provinces, with a growing petrochemical industry in Alberta, accounts for 26% of production followed by Quebec with 17%, British Columbia with 4% and the Atlantic Provinces with just 2%.

Canada manufactures 5 times more inorganic than organic chemicals. Sulphuric acid is the single most important compound in the grouping, its production averaging some 3 million tons a year. Other important compounds are sodium hydroxide,

chlorine, hydro-carbons such as ethylene, alcohols, plastics and resins. The Chemical industry is capital intensive with an average annual growth rate of 13.5% in real terms from 1970-1975, and tends to lead overall industrial production in growth, the latter experiencing only a moderate increase of 3.9% per year. In 1973 and 1974 sharply increased world demand and high prices caused a boom in the Chemical industry. However, a drop in demand in 1975 has since dampened the market and, even though trading activities increased in 1977, it is felt that a situation with excess supply is likely to exist for the next few years leading to a lower growth rate for the industry. Future expansion, especially in Ontario, will also be limited by the slow down and even closure of some mining operations, from which manufacturers derive their raw materials, and by the increasingly stringent environmental protection measures which restrict the choice of plant location and the allowable levels of pollution.

Some suppliers are oriented to the export market, mainly in the United States, while others are committed to the domestic market, exporting only when there is a surplus. The levels of these surpluses are affected by the investment cycles in the Chemicals industry. When new plants are built or existing ones upgraded, the Chemical companies tend to add capacity far in excess of present demand in order to accommodate anticipated future growth in domestic consumption. Initially therefore there is a strong incentive to dispose of the surplus through exports thereby creating peaks in the commodity flow patterns. In this situation of over-supply, when the exporters in order to maintain their competitive positions sell the excess at cost to markets

further away, extra transportation costs are incurred. Note that the Canadian regions compete among themselves for the domestic market. Thus Alberta, for example, supplies Central Canada with raw chemicals used in the manufacture of finished goods which subsequently compete with similar finished goods produced in Alberta and shipped to Ontario and Quebec.

The United States multinational corporations own most of the larger chemical plants in Canada and as such both exports to and imports from the United States are handled through corporate market networks. For exports to the United States, organic chemicals are subject to tariffs of 10 to 12% while some inorganic compounds such as the acids are tariff free. For imports into Canada, tariffs ranging up to 15% are generally imposed. It is expected that current discussions under the General Agreement on Trade and Tariffs (GATT) will result in some tariff reduction.

For the period 1971-1975, exports were estimated at 1.7 million tons and imports at 2.4 million tons annually, thus making Canada a net importer of Chemicals. Transborder shipments accounted for 80% of this trade while Western Europe accounted for 11% of the exports and 16% of the imports and the remainder of the trade was with fringe markets around the world. Ontario is the major domestic market accounting for 50% of both exports and imports followed by Quebec with 25%.

Rail is the predominant mode of transport for chemicals: domestically about 5 million tons are loaded onto railway cars annually. Rail moves about 48% of the exports to the United States and receives an estimated 57% of the imports from the United States. Trucking represents another 33% of transborder shipments with marine accounting for approximately 17%. Small quantities of less than 10,000 tons destined for off shore markets are sometimes moved by rail and truck from the Prairie Provinces and Ontario to the United States ports for final shipment. The rail mode is also used to tranship some Chemicals from the Prairie Provinces to the St. Lawrence and Atlantic ports. However, these transhipments are not included in the movements under study. Domestic marine shipments have averaged 800,000 tons per year with 75% of these movements occurring within Ontario and British Columbia.

For some of the low value Chemicals, such as sulphuric acid in solution, rail freight rates can account for as much as 50% of the selling price while for the higher value hydrocarbons rail freight rates constitute perhaps no more than 10% of the price. Some hydrocarbons are transported by pipeline across the border, and also from Alberta to Central Canada but this mode is not yet very significant in the transport of Chemicals.

The time series analysis was applied to 11 Chemical links: apart from 2 domestic marine links, they represented exports to and imports from the United States and Western Europe. The observed period extended from January 1966 to December 1975. Once acceptable time series models were obtained, monthly forecasts were aggregated into annual figures and, wherever possible, compared with the results from the earlier regression model. Note that although both methods used the same data source, i.e. External Trade, the observed period for the regression model ended in 1974. This model used as explanatory variables: the production of Chemicals, the value and index of manufacturing production and the production of Woodpulp.

For the forecast period to 1985, most of the variables were obtained indirectly from CANDIDE, the macroeconomic model of the Canadian Economy constructed by the Economic Council of Canada: the others were projected from time trends. Generally, the net contribution of these variables was to provide forecasts of the movements of Chemicals which increased moderately until 1985.

6.2 Marine Movements of Chemicals within Ontario

Data on monthly marine movements of Chemicals within Ontario from January 1966 to December 1975 in thousands of tons appear in Figure 6.1. The highly seasonal pattern of the flows reflect the ice-bound conditions of the Great Lakes and the Seaway: no definite trend is apparent. Most of the movements are outflows from Sarnia and inflows to the Lakehead. If Z_t represents the movement during month t in millions of tons then Z_t may be described by a seasonal time series model

$$W_t = (1 - \underset{(\pm 0.072)}{0.822}\, B^{12})a_t$$

where $W_t = \nabla_{12} Z_t$ and the residual standard error is estimated to be 0.106. Diagnostic checks applied to the residuals indicate that the model is adequate.

The model suggests that the data is homogeneous non-stationary together with a seasonal component without trend: monthly forecasts to December 1985 using this model also appear in Figure 6.1 together with their 75% confidence limits, and the pronounced seasonality is repeated throughout the forecast period. The data and forecasts on an annual basis are given in Table 6.1 and are compared with data and forecasts from the earlier regression model in Figure 6.2. The regression model projects an upward trend for the flows reaching around 320,000 tons by 1985. By contrast, the time series analysis whose forecasts begin in 1976, projects a constant level of flow at about 210,000 tons to 1985. Very possibly, Chemicals shipped by marine mode are used in mining operations and the pulp and paper industry in Northern Ontario. Given low growth in these industries and the fact that the marine mode is only a secondary mode for transporting Chemicals it is felt that the forecasts from the time series model might represent a more accurate picture.

Table 6.1: Annual marine movements of Chemicals within Ontario in thousands of tons: the forecasts were derived from the time series model

Year	Data	Year	Forecasts
1966	148	1978	210
67	122	79	210
68	170	80	210
69	223	81	210
70	201	82	210
71	255	83	210
72	181	84	210
73	198	85	210
74	203		
75	288		

Figure 6.1: Monthly marine movements of Chemicals within Ontario in thousands of tons

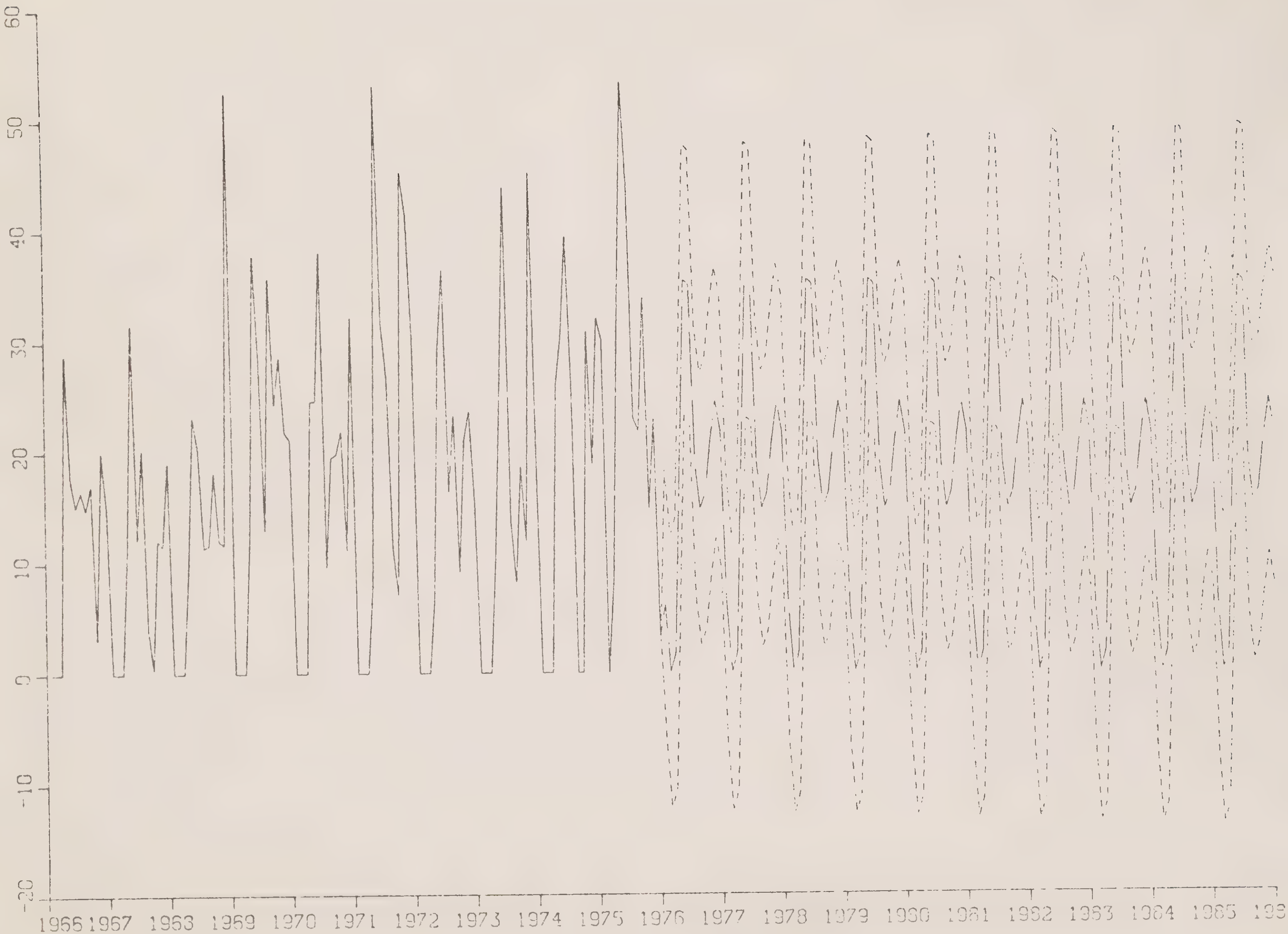
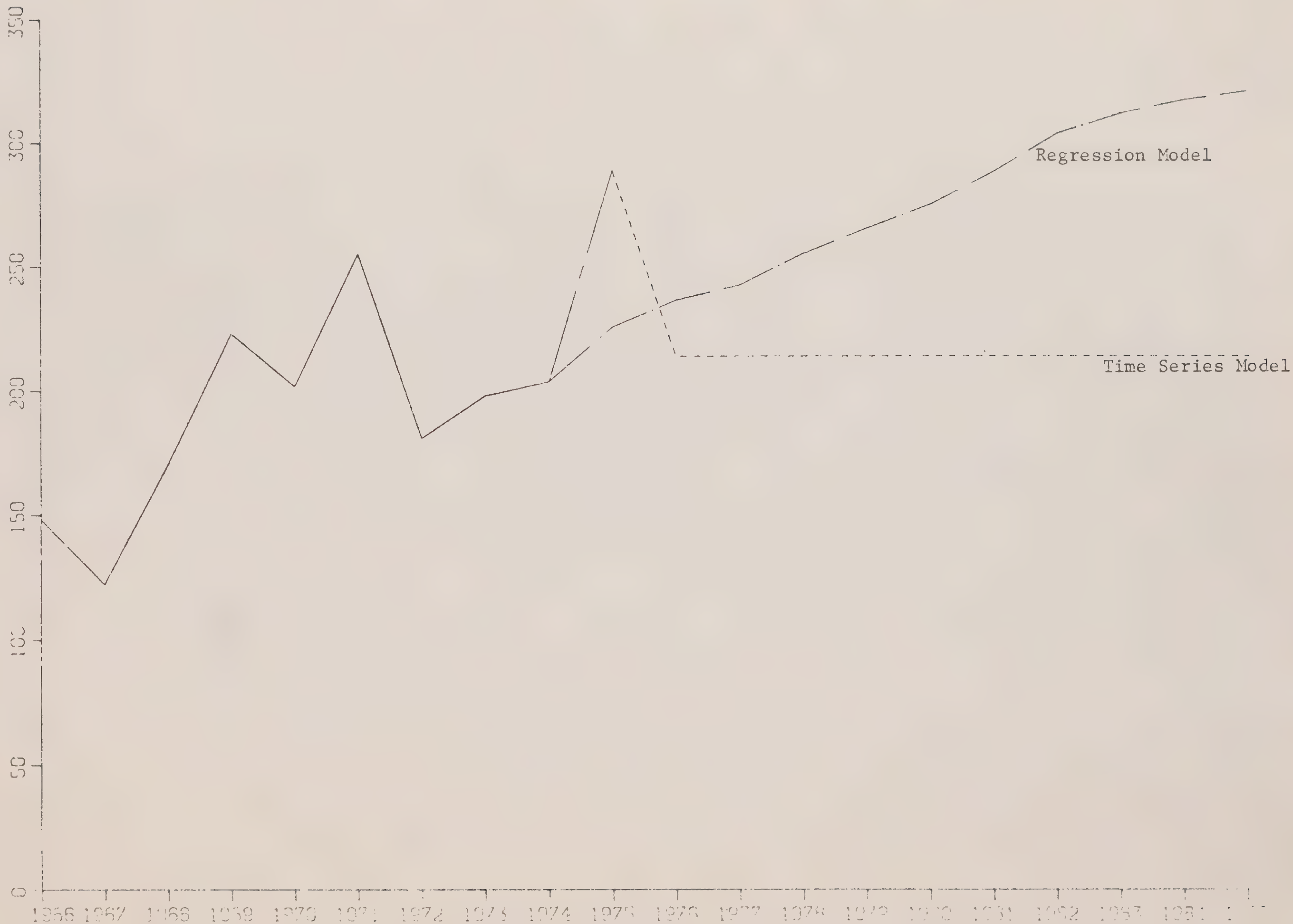


Figure 6.2: A comparison between the Regression Model and the Time Series Model for the Annual marine movements of Chemicals within Ontario in thousands of tons



6.3 Marine Movements of Chemicals within British Columbia

Data on monthly marine movements of Chemicals within British Columbia from January 1966 to December 1975 in thousands of tons appear in Figure 6.3. With no ice-bound conditions existing on the West Coast, there is no noticeable seasonal pattern. Outflows from Vancouver to the smaller coastal cities and Price Rupert in the North account for a large part of the movement. If Z_t represents the movement during month t in millions of tons then Z_t may be described by an autoregressive time series model

$$(1 - \underset{(\pm 0.168)}{0.351} B - \underset{(\pm 0.168)}{0.377} B^2)\tilde{Z}_t = a_t$$

$$\tilde{Z}_t = Z_t - \underset{(\pm 0.007)}{0.032}$$

and the residual standard error is estimated to be 0.0108. Diagnostic checks applied to the residuals indicate the model is satisfactory.

The model indicates that the data is stationary with no seasonal component: monthly forecasts to December 1985 using this model also appear in Figure 6.3 together with their 75% confidence limits. The data and forecasts on an annual basis are given in Table 6.2 and are compared with data and forecasts from the earlier regression model in Figure 6.4. The regression model projects sustained growth for this link, reaching perhaps 1.0 million tons by 1985. By contrast the time series model forecasts a slight recovery after 1975, to 380,000 tons by 1977, when it will stay approximately constant to 1985. No significant growth is expected in the marine transportation of Chemicals unless the pulp and paper industry and mining activities expand.

Table 6.2: Annual marine movements of Chemicals within British Columbia in thousands of tons: forecasts were derived from the time series model

Year	Data	Year	Forecasts
1966	271	1978	380
67	294	79	380
68	228	80	380
69	551	81	380
70	477	82	380
71	527	83	380
72	506	84	380
73	396	85	380
74	392		
75	217		

Figure 6.3: Monthly marine movements of Chemicals within British Columbia in thousands of tons

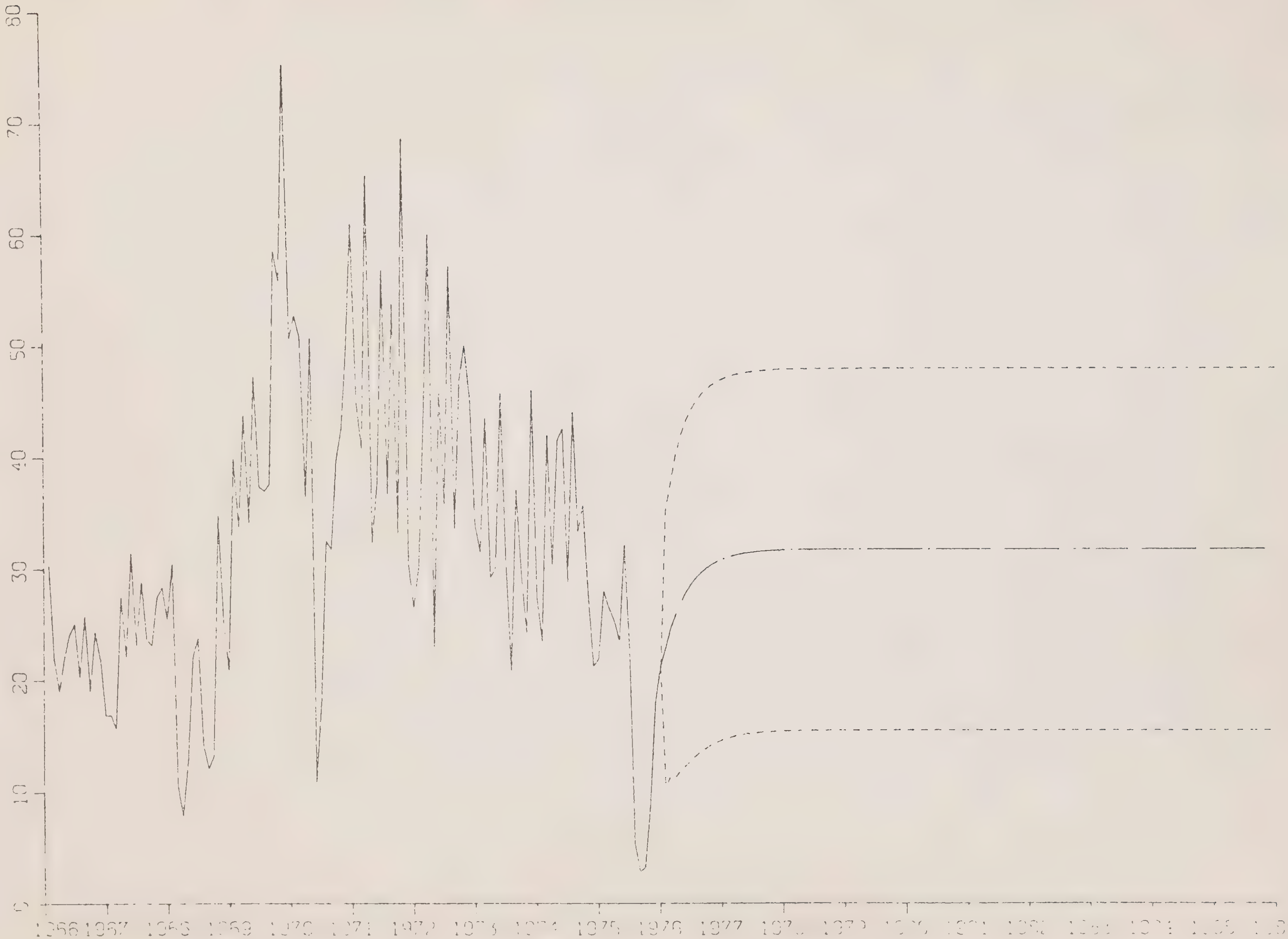
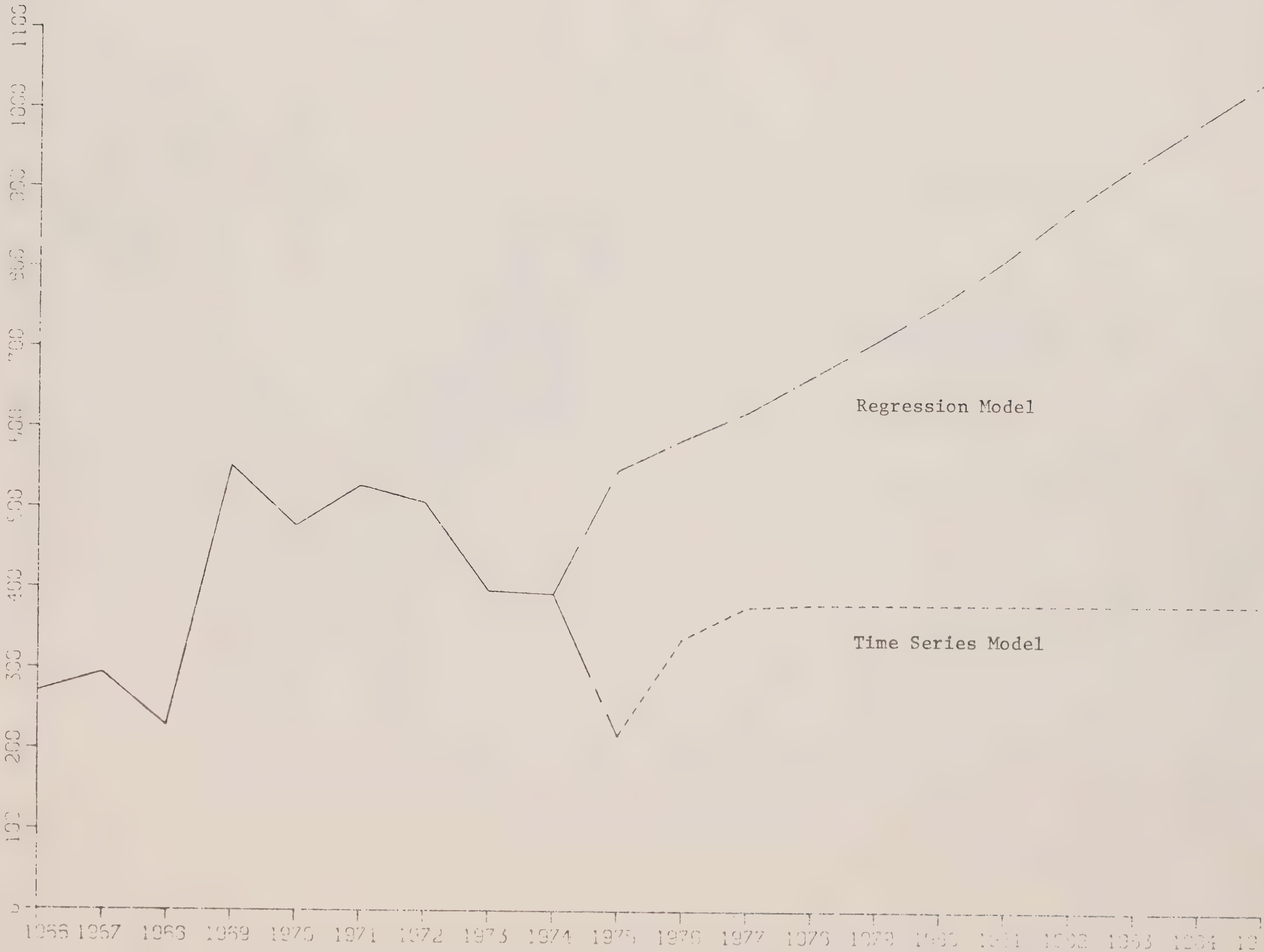


Figure 6.4: A comparison between the Regression Model and the Time Series Model for the Annual marine movements of Chemicals within British Columbia in thousands of tons



6.4 Marine Exports of Chemicals from the Atlantic Provinces to Western Europe

Data on monthly marine exports of Chemicals from the Atlantic Provinces to Western Europe from January 1966 to December 1975 appear in Figure 6.5. The movements in the observed period have no trend, do not seem to exhibit any definite seasonal pattern and are small in volume, averaging only 39,000 tons annually from 1971-1975. Thus the single monthly shipment of some 55,000 tons in 1970 presents a rather sharp peak. Exports to Western Europe were higher than average in 1969 and 1970 because of a slightly depressed domestic market. If Z_t represents the movement during month t in millions of tons then Z_t may be described by

$$\tilde{Z}_t = Z_t - \underset{(\pm 0.001)}{0.00285} = a_t$$

where the residual standard error is estimated to be 0.00532. Apart from the marked outlier in 1970, the series appears as random fluctuations about a constant level, and no autoregressive or moving average parameters are significant. As a result monthly forecasts are constant and appear in Figure 6.5 to 1985 together with their 75% confidence limits.

The data and forecasts on an annual basis are given in Table 6.3 and are compared with data and forecasts from the earlier regression model in Figure 6.6. The regression model projects little growth in exports from the Atlantic Provinces to Western Europe, reaching only 54,000 tons by 1985. The time series results show a slight recovery from 29,000 tons in 1975 to 34,000 tons in 1976 and remains constant at this level to 1985. The Atlantic Provinces account for only a small share of Canadian Chemicals production and the Western

European market accepts only a limited quantity of Chemicals from Canada. It is likely that the overall level of exports will not grow noticeably although significant peaks may occur during times of surplus.

Table 6.3: Annual marine exports of Chemicals from the Atlantic Provinces to Western Europe in thousands of tons: the forecasts were derived from the time series model

Year	Data	Year	Forecasts
1966	4	1978	34
67	7	79	34
68	12	80	34
69	27	81	34
70	97	82	34
71	39	83	34
72	38	84	34
73	44	85	34
74	46		
75	29		

Figure 6.5: Monthly marine exports of Chemicals from the Atlantic Provinces to Western Europe in thousands of tons

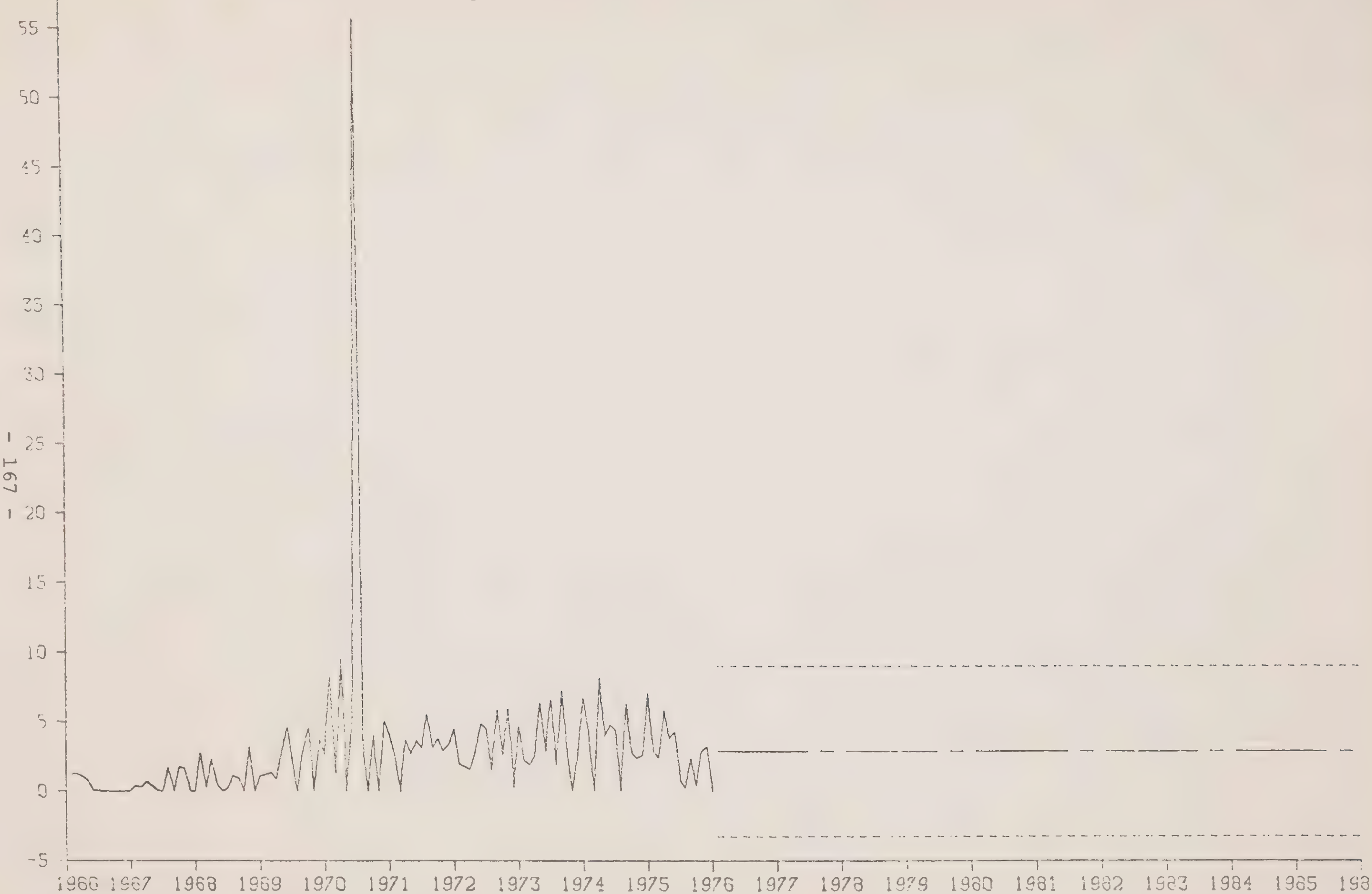
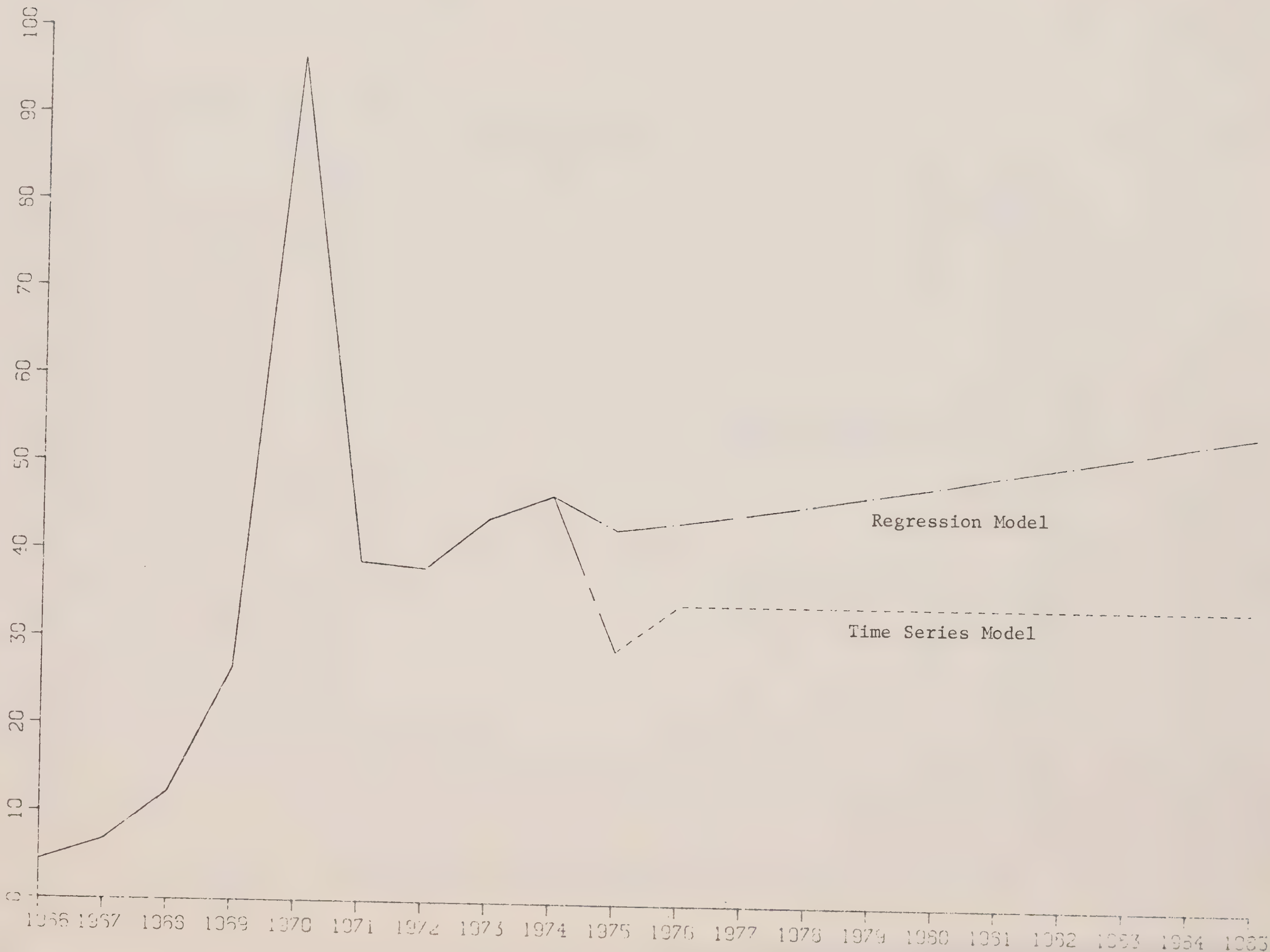


Figure 6.6: A comparison between the Regression Model and the Time Series Model for the Annual marine exports of Chemicals from the Atlantic Provinces to Western Europe in thousands of tons



6.5 Marine Exports of Chemicals from Quebec to Western Europe

Data on monthly exports of Chemicals from Quebec to Western Europe from January 1966 to December 1975 in thousands of tons appears in Figure 6.7. A mild recession in domestic consumption increased exports in 1970. If Z_t represents the movement during month t in millions of tons then Z_t may be described by

$$\tilde{Z}_t = Z_t - \underset{(\pm 0.00044)}{0.00520} = a_t$$

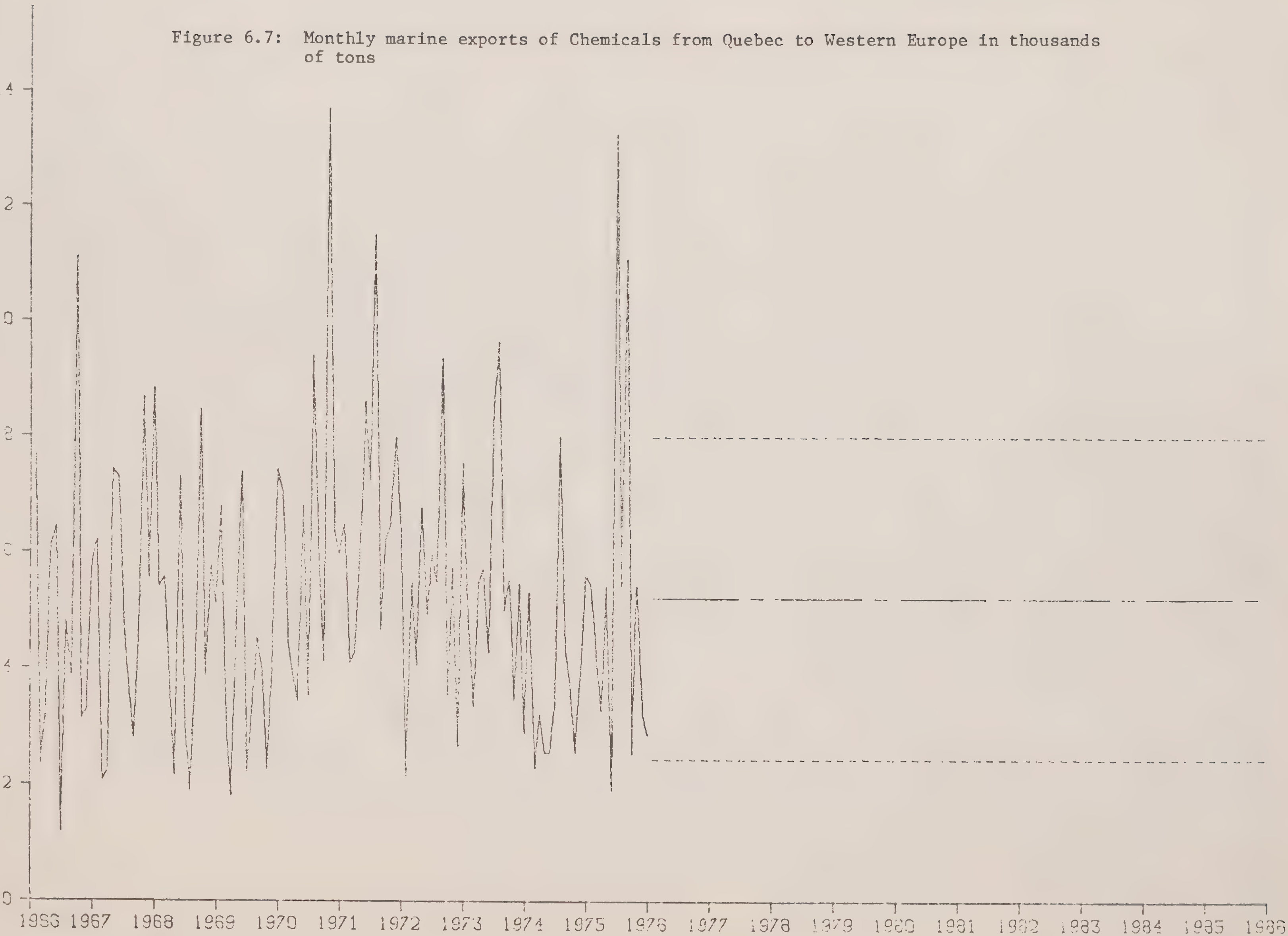
where the residual standard error is estimated to be 0.00241. The series appears as random fluctuations about a constant level and no autoregressive or moving average parameters are required. As a result monthly forecasts are constant and appear in Figure 6.7 to 1985 together with their 75% confidence limits.

Forecasts on an annual basis are given in Table 6.4 but were not compared with the earlier regression model since the time series data included some shipments from Quebec to countries in Western Europe outside the original European Economic Community or the United Kingdom so that the results from the two models are not directly comparable. No significant growth in this link is anticipated. Western Europe is a minor market compared to the United States.

Table 6.4: Annual marine exports of Chemicals from Quebec to Western Europe in thousands of tons: the forecasts were derived from the time series model

Year	Data	Year	Forecasts
1966	59	1978	62
67	65	79	62
68	56	80	62
69	52	81	62
70	75	82	62
71	80	83	62
72	64	84	62
73	64	85	62
74	47		
75	64		

Figure 6.7: Monthly marine exports of Chemicals from Quebec to Western Europe in thousands of tons



6.6 Marine Exports of Chemicals from Ontario to Western Europe

Data on monthly marine exports of Chemicals from Ontario to Western Europe from January 1966 to December 1975 in thousands of tons appear in Figure 6.8. If Z_t represents the movement during month t in millions of tons then Z_t may be described by a seasonal time series model

$$W_t = (1 - \underset{(\pm 0.175)}{0.574}\, B^{12})\, a_t$$

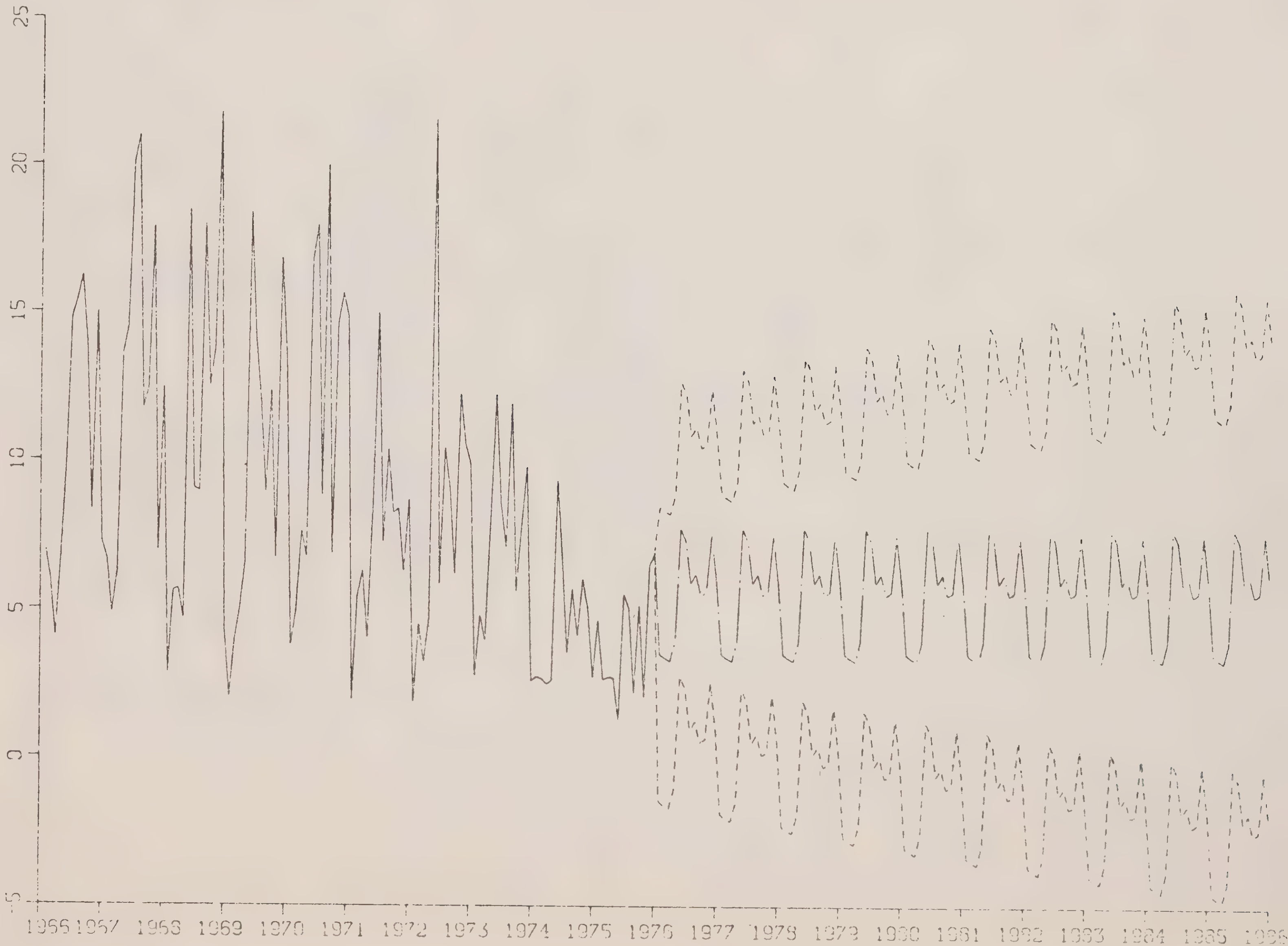
where $W_t = \nabla_{12} Z_t$ and the residual standard error is estimated to be 0.00431. Diagnostic checks applied to the residuals indicate that the model is adequate.

The model suggests that the series is homogeneous non-stationary with a seasonal component but without trend: monthly forecasts to December 1985 using this model also appear in Figure 6.8 together with their 75% confidence limits. The data and forecasts on an annual basis are given in Table 6.5 but were not compared with the earlier regression model since for the time series data some shipments were made from Ontario to countries in Western Europe outside the original European Economic Community or the United Kingdom so that the results from the two models are not directly comparable. Although no growth is expected in this link it is expected to exist at a low level without disappearing as the trend might seem to suggest.

Table 6.5: Annual marine exports of Chemicals from Ontario to Western Europe in thousands of tons: the forecasts were derived from the time series model

Year	Data	Year	Forecasts
1966	125	1978	66
67	148	79	66
68	126	80	66
69	120	81	66
70	138	82	66
71	90	83	66
72	100	84	66
73	85	85	66
74	54		
75	47		

Figure 6.8: Monthly marine exports of Chemicals from Ontario to Western Europe in thousands of tons



6.7 Rail Exports of Chemicals from Quebec to the United States

Data on monthly rail exports of Chemicals from Quebec to the United States from January 1966 to December 1975 in thousands of tons appears in Figure 6.9. New plant start-ups probably caused the rise in exports in 1969 while increased demand accounted for the increases in 1973 and 1974. If Z_t represents the movement during month t in millions of tons then Z_t may be described by an autoregressive time series model

$$(1 - \underset{(\pm 0.176)}{0.449}\, B - \underset{(\pm 0.178)}{0.244}\, B^2)\tilde{Z}_t = a_t$$

$$\tilde{Z}_t = Z_t - \underset{(\pm 0.001)}{0.007}$$

and the residual standard error is estimated to be 0.0015. Diagnostic checks applied to the residuals indicate that the model is adequate.

The model indicates that the series is stationary about a constant level: monthly forecasts to December 1985 using this model also appear in Figure 6.9 together with their 75% confidence limits. The data and forecasts on an annual basis are given in Table 6.6 and are compared with data and forecasts from the earlier regression model in Figure 6.10. This model predicted continuous growth to 1985. By contrast, the time series results show an eventual constant flow of about 84,000 tons to 1985.

There is probably no basis for projecting growth in organic Chemical production and competition from Ontario and Alberta

may slow down investment in petrochemicals. However it is expected that Quebec will increase its output of Chlorine and Sodium Hydroxide to the extent that an overall increase in exports to the United States is expected. It would seem then that the regression model might present a more realistic view in that it forecasts growth.

Table 6.6: Annual rail movements of Chemicals from Quebec to the United States in thousands of tons: the forecasts were derived from the time series model

Year	Data	Year	Forecasts
1966	87	1978	84
67	81	79	84
68	87	80	84
69	106	81	84
70	75	82	84
71	50	83	84
72	58	84	84
73	99	85	84
74	104		
75	87		

Figure 6.9: Monthly rail movements of Chemicals from Quebec to the United States in thousands of tons

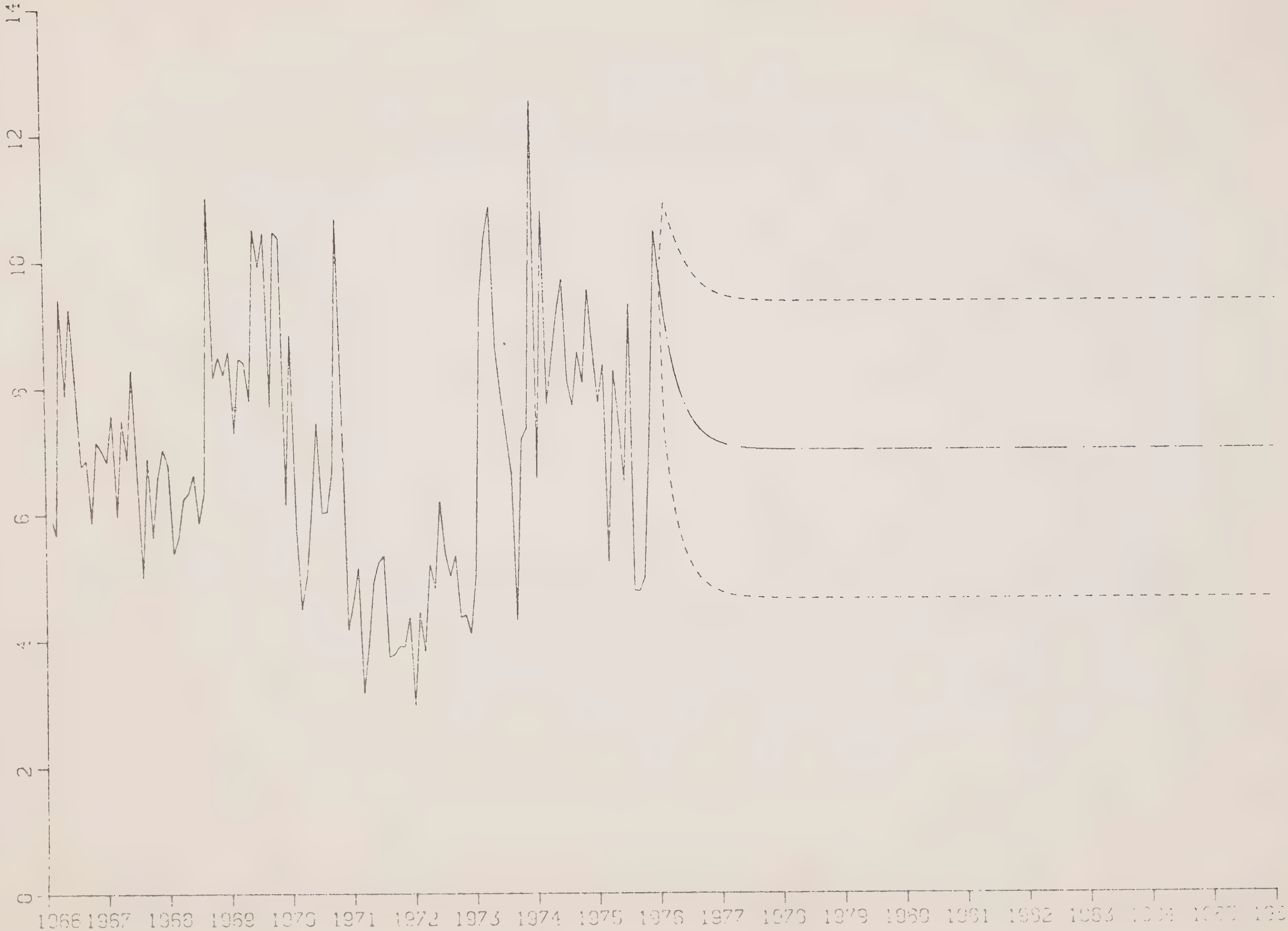
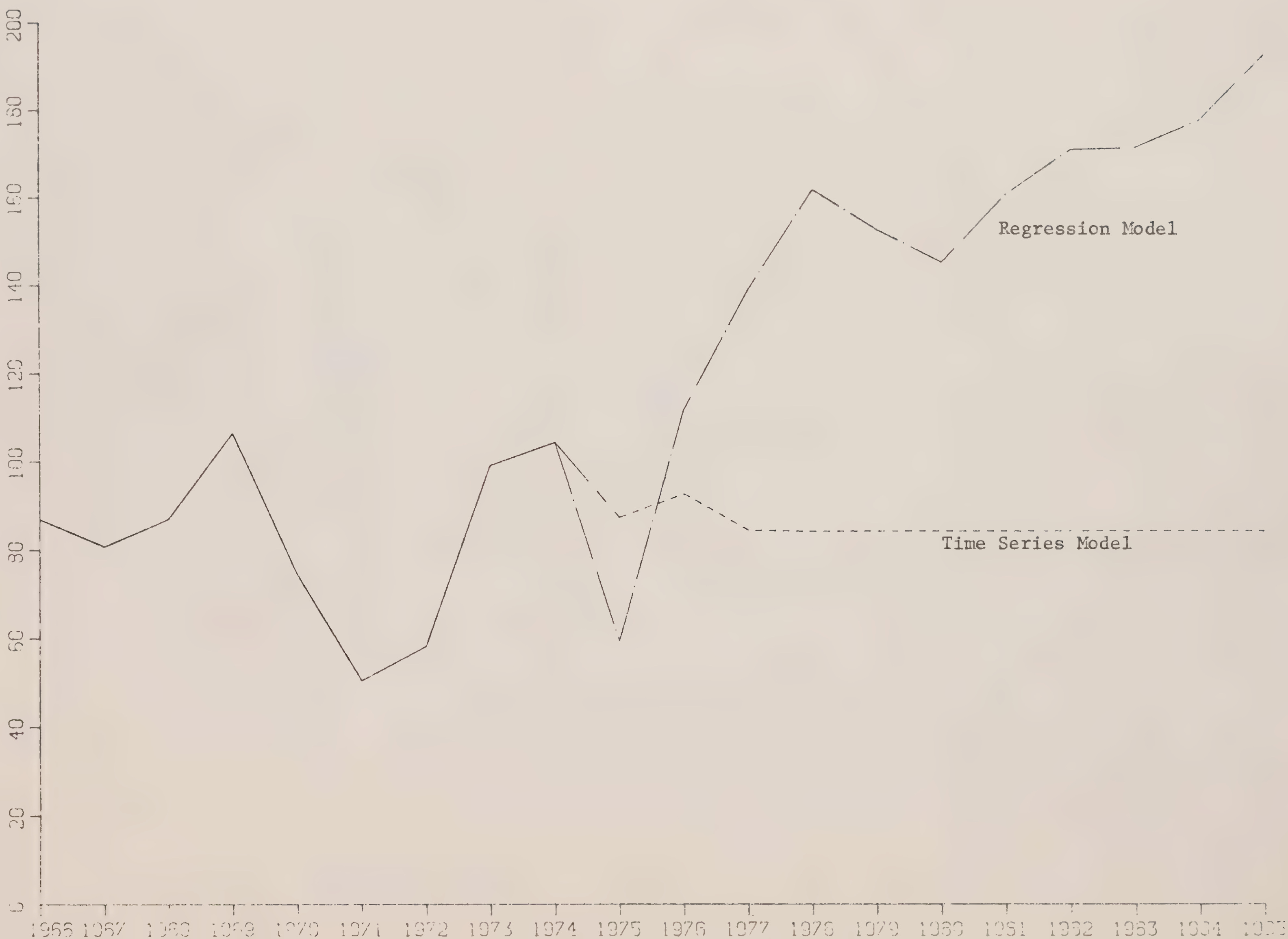


Figure 6.10: A comparison between the Regression Model and the Time Series Model for the Annual rail movement of Chemicals between Quebec and the United States in thousands of tons



6.8 Rail Exports of Chemicals from Ontario to the United States

Data on monthly rail exports of Chemicals from Ontario to the United States from January 1966 to December 1975 in thousands of tons appear in Figure 6.11. High demand in 1974 caused the observed increase in the movement. If Z_t represents the movement during month t in millions of tons then Z_t may be described by a multiplicative seasonal time series model

$$(1 - \underset{(\pm 0.179)}{0.477}\, B - \underset{(\pm 0.180)}{0.200}\, B^2)\tilde{Z}_t = (1 + \underset{(\pm 0.188)}{0.204}\, B^{12})a_t$$

$$\tilde{Z}_t = Z_t - \underset{(\pm 0.0035)}{0.0280}$$

where the residual standard error is estimated to be 0.0054. Diagnostic checks applied to the residuals indicate that the model is adequate.

The model suggests that the series is stationary with a secondary seasonal component about a constant level: monthly forecasts to December 1985 using this model also appear in Figure 6.11 together with their 75% confidence limits. The data and forecasts on an annual basis are given in Table 6.7 and are compared with data and forecasts from the earlier regression model in Figure 6.12. The regression model employed annual data from the Railway Freight Traffic computer tapes and unfortunately the data were not corrected for the United States to United States flows via Canada which accounted for approximately 70% of the movements. This model projects moderate growth for future exports to the United States, reaching perhaps 640,000 tons by 1985. The time series analysis predicts a constant annual level of 330,000 tons to 1985. Ontario has recently finished a billion dollar investment program in the Chemical industry and an oversupply of organic Chemicals is expected: increases in

production could be as high as 8% per year. In addition there are surpluses of inorganic Chemicals such as sulphuric acid. With the pressure to export more to the United States, opinion suggests that the regression model might indicate a more accurate trend.

Table 6.7: Annual rail exports of Chemicals from Ontario to the United States in thousands of tons: the forecasts were derived from the time series model

Year	Data	Year	Forecasts
1966	228	1978	30
67	237	79	30
68	322	80	30
69	362	81	30
70	385	82	30
71	347	83	30
72	311	84	30
73	355	85	30
74	440		
75	360		

Figure 6.11: Monthly rail exports of Chemicals from Ontario to the United States in thousands of tons

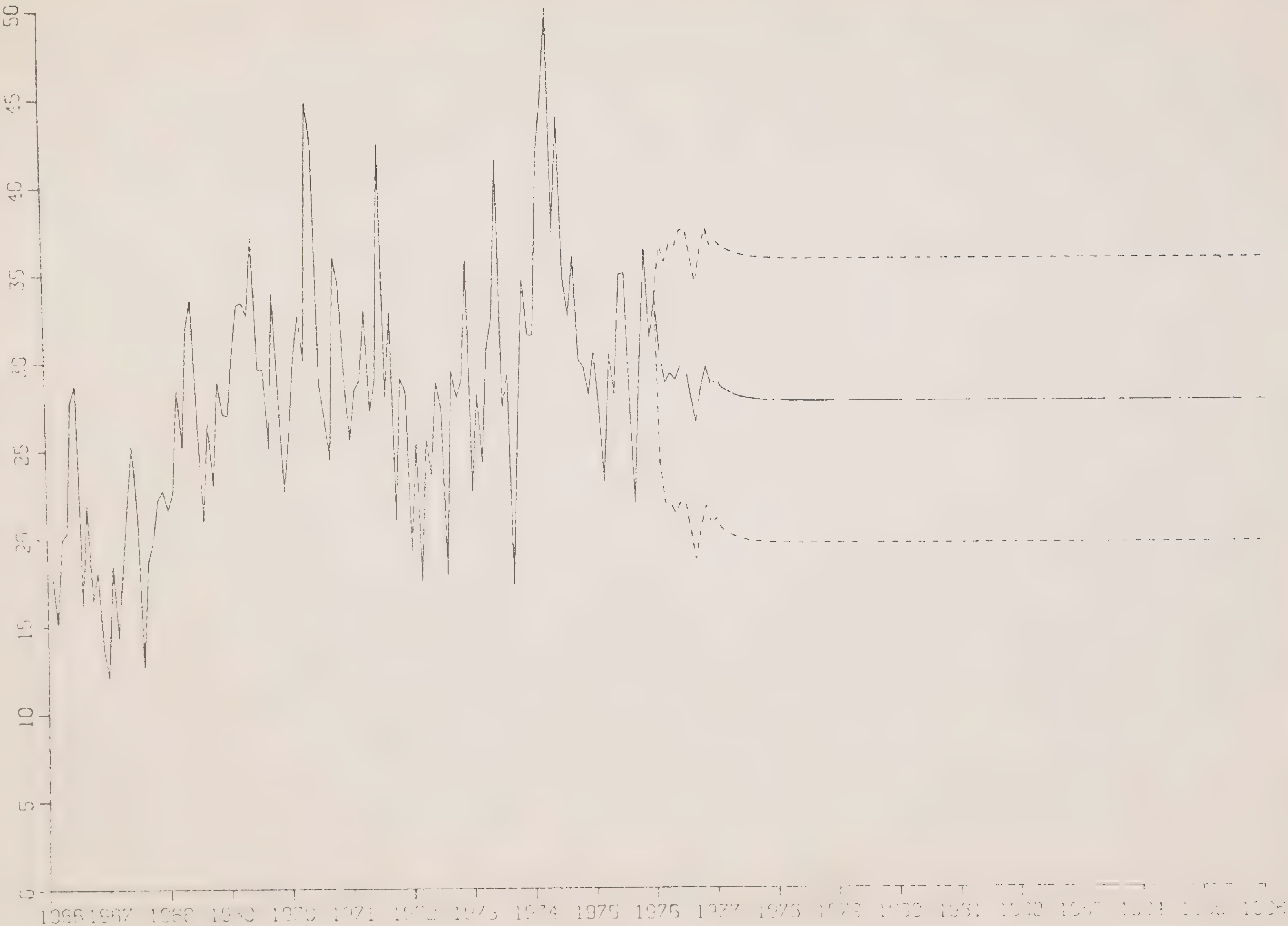
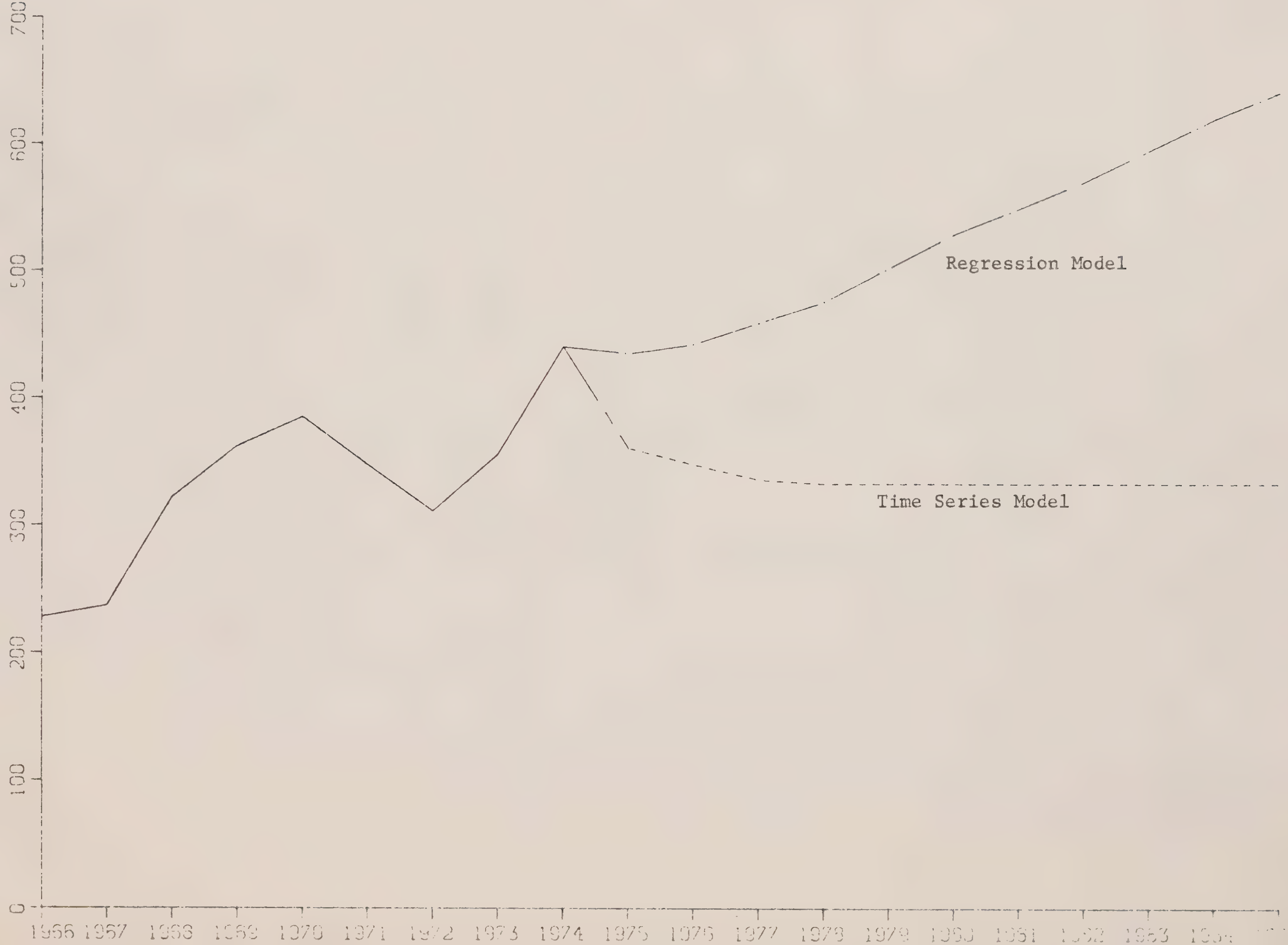


Figure 6.12: A comparison between the Regression Model and the Time Series Model for the Annual rail export of Chemicals from Ontario to the United States in thousands of tons



6.9 Rail Exports of Chemicals from the Prairie Provinces to the United States

Data on monthly rail exports of Chemicals from the Prairie Provinces to the United States from January 1966 to December 1985 in thousands of tons appear in Figure 6.13. The addition of new Chemical plants in 1973 and 1974 boosted exports considerably. If Z_t represents the movement during month t in millions of tons then Z_t may be described by an autoregressive time series model

$$(1 - \underset{(\pm 0.167)}{0.483}\, B - \underset{(\pm 0.168)}{0.384}\, B^2)\tilde{Z}_t = a_t$$

$$\tilde{Z}_t = Z_t - \underset{(\pm 0.0035)}{0.0138}$$

and the residual standard error is estimated to be 0.0028. Diagnostic checks applied to the residuals indicate a marginally significant autocorrelation function at lags 6 and 7 but otherwise the model is judged adequate.

The model suggests that the series is stationary about a constant level with no seasonal component: monthly forecasts to December 1985 also appear in Figure 6.13 together with their 75% confidence limits. The data and forecasts on an annual basis are given in Table 6.8 and are compared with data and forecasts from the earlier regression model in Figure 6.14. A steady growth trend after 1976 is predicted by the regression model while the time series analysis projects a rather significant drop to a constant export level of 170,000 tons annually. The petrochemical industry in Alberta is growing and there are plans for a major investment in 1979 and 1980. An addition of no less than 100,000 tons to the level of exports is expected. Thus, the regression model would seem to indicate a more accurate picture of the level of future exports.

Table 6.8: Annual rail exports of Chemicals from the Prairie Provinces to the United States in thousands of tons: the forecasts were derived from the time series model

Year	Data	Year	Forecasts
1966	114	1978	170
67	151	79	170
68	134	80	170
69	141	81	170
70	131	82	170
71	148	83	170
72	162	84	170
73	161	85	170
74	271		
75	245		

Figure 6.13: Monthly rail exports of Chemicals from the Prairie Provinces to the United States in thousands of tons

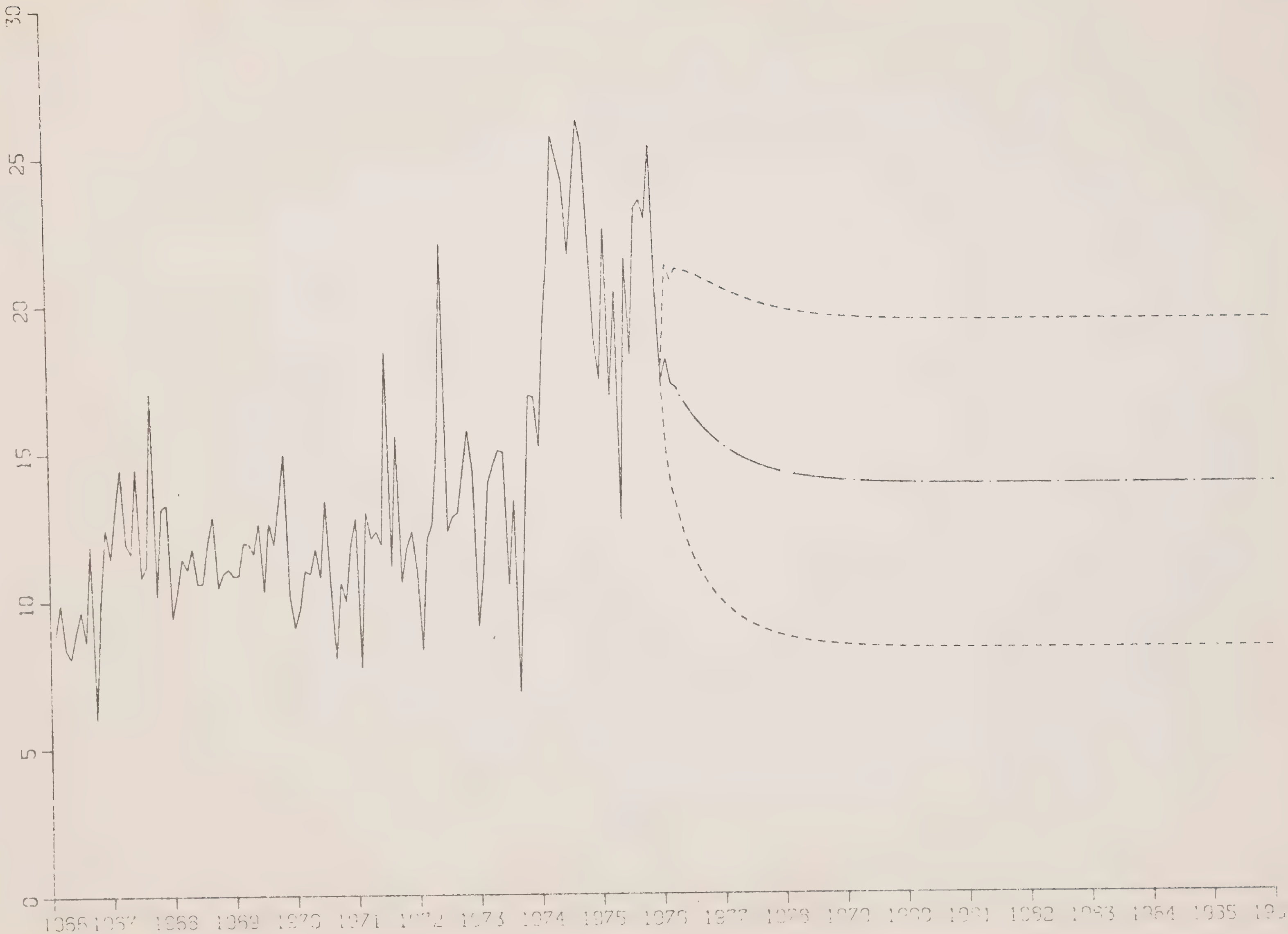
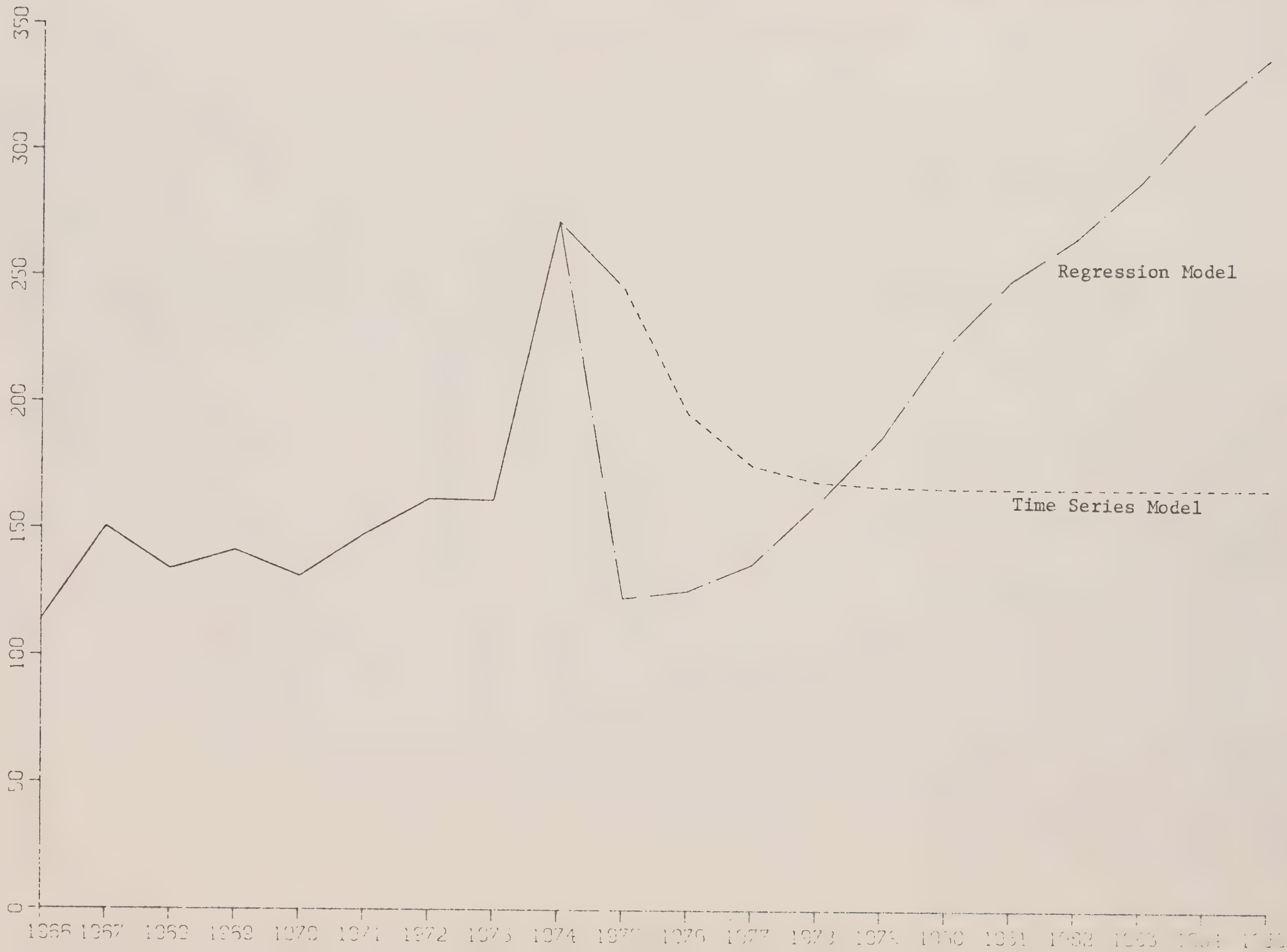


Figure 6.14: A comparison between the Regression Model and the Time Series Model for the Annual rail export of Chemicals from the Prairie Provinces to the United States in thousands of tons



6.10 Imports of Chemicals from Western Europe to Ontario

Data on monthly imports of Chemicals from Western Europe to Ontario from January 1966 to December 1975 in thousands of tons appears in Figure 6.15. These are, of course, almost entirely by the marine mode. The concentration of shipments to certain months led to some peaking effects in the observed data and the ice bound conditions of the Seaway created a seasonal pattern. If Z_t represents the movement during month t in millions of tons then Z_t may be described by a multiplicative seasonal time series model.

$$\underset{(\pm 0.112)}{(1 - 0.932\ B)}W_t = \underset{(\pm 0.217)}{(1 - 0.677\ B)}\ \underset{(\pm 0.113)}{(1 - 0.737\ B^{12})}a_t$$

where $W_t = \nabla_{12} Z_t$ and the residual standard error is estimated to be 0.0019. Diagnostic checks applied to the residuals indicate that the model is adequate.

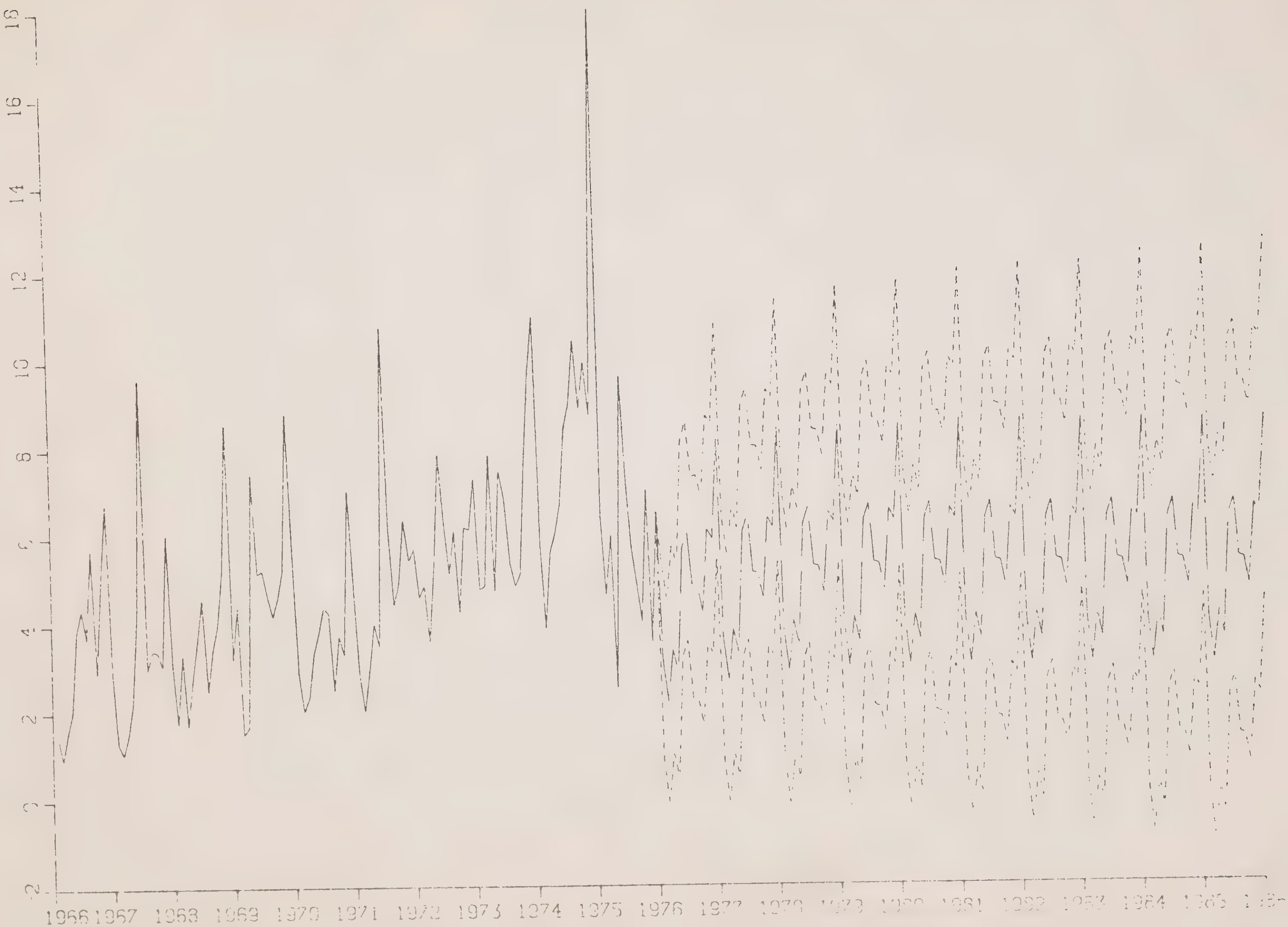
The model suggests that the series is homogeneous non-stationary together with a seasonal component without trend: monthly forecasts to December 1985 using this model also appear in Figure 6.15 together with their 75% confidence limits, and the seasonal component is apparent throughout the forecast period.

The data and forecasts on an annual basis are given in Table 6.9 but are not compared with the earlier regression model, since shipments from Western Europe were amalgamated with shipments from Asia and Latin America into a general 'Foreign' category in the regression model, so that results from the two models are not directly comparable. Western Europe is only a minor supplier of Chemicals to Ontario and, with the growth in the domestic petrochemical industry, this link is not expected to increase significantly.

Table 6.9: Annual imports of Chemicals from Western Europe to Ontario in thousands of tons: the forecasts were derived from the time series model

Year	Data	Year	Forecasts
1966	41	1978	64
67	42	79	64
68	45	80	65
69	59	81	65
70	45	82	65
71	59	83	65
72	68	84	65
73	80	85	65
74	102		
75	68		

Figure 6.15: Monthly imports of Chemicals from Western Europe to Ontario in thousands of tons



6.11 Imports of Chemicals from the United States to Ontario

Data on monthly imports of Chemicals from the United States to Ontario from January 1966 to December 1975 in thousands of tons appear in Figure 6.16. Ontario is the largest Canadian consumer of Chemicals from the United States and inflationary demand in 1973 and 1974 caused a significant increase in the imports. The mode of transportation is unknown and involves rail, marine and trucking each in significant proportion. If Z_t represents the movement during month t in millions of tons then Z_t may be described by a multiplicative seasonal time series model

$$W_t = \underset{(\pm 0.159)}{(1 - 0.491\ B)}\ \underset{(\pm 0.179)}{(1 + 0.369\ B^{12})}a_t$$

where $W_t = \nabla Z_t$ and the residual standard error is estimated to be 0.0085. Diagnostic checks applied to the residuals indicate a marginally significant value of the autocorrelation function at lag 21 but otherwise the model is judged adequate.

The model suggests that the series is homogeneous non-stationary together with a seasonal component without trend: monthly forecasts to December 1985 using this model also appear in Figure 6.16 together with their 75% confidence limits. The seasonal component of the shipments was probably due to the seasonality of the marine movements.

The data and forecasts on an annual basis are given in Table 6.10 and are compared with data and forecasts from the earlier regression model in Figure 6.17. With new investment in petrochemical processing in Ontario, imports of organic chemicals are expected to fall. United States shipments of inorganic compounds will at best grow very moderately although imports of Chemical specialties might increase at a higher rate.

The overall picture would seem to indicate little or no growth with the possibility of a slight decline. The time series model would seem to serve as a better indicator of future trends.

Table 6.10: Annual imports of Chemicals from the United States to Ontario in thousands of tons: the forecasts were derived from the time series model

Year	Data	Year	Forecasts
1966	642	1978	1,110
67	652	79	1,110
68	713	80	1,110
69	882	81	1,110
70	800	82	1,110
71	807	83	1,110
72	1,009	84	1,110
73	1,227	85	1,110
74	1,256		
75	1,073		

Figure 6.16: Monthly imports of Chemicals from the United States to Ontario in thousands of tons

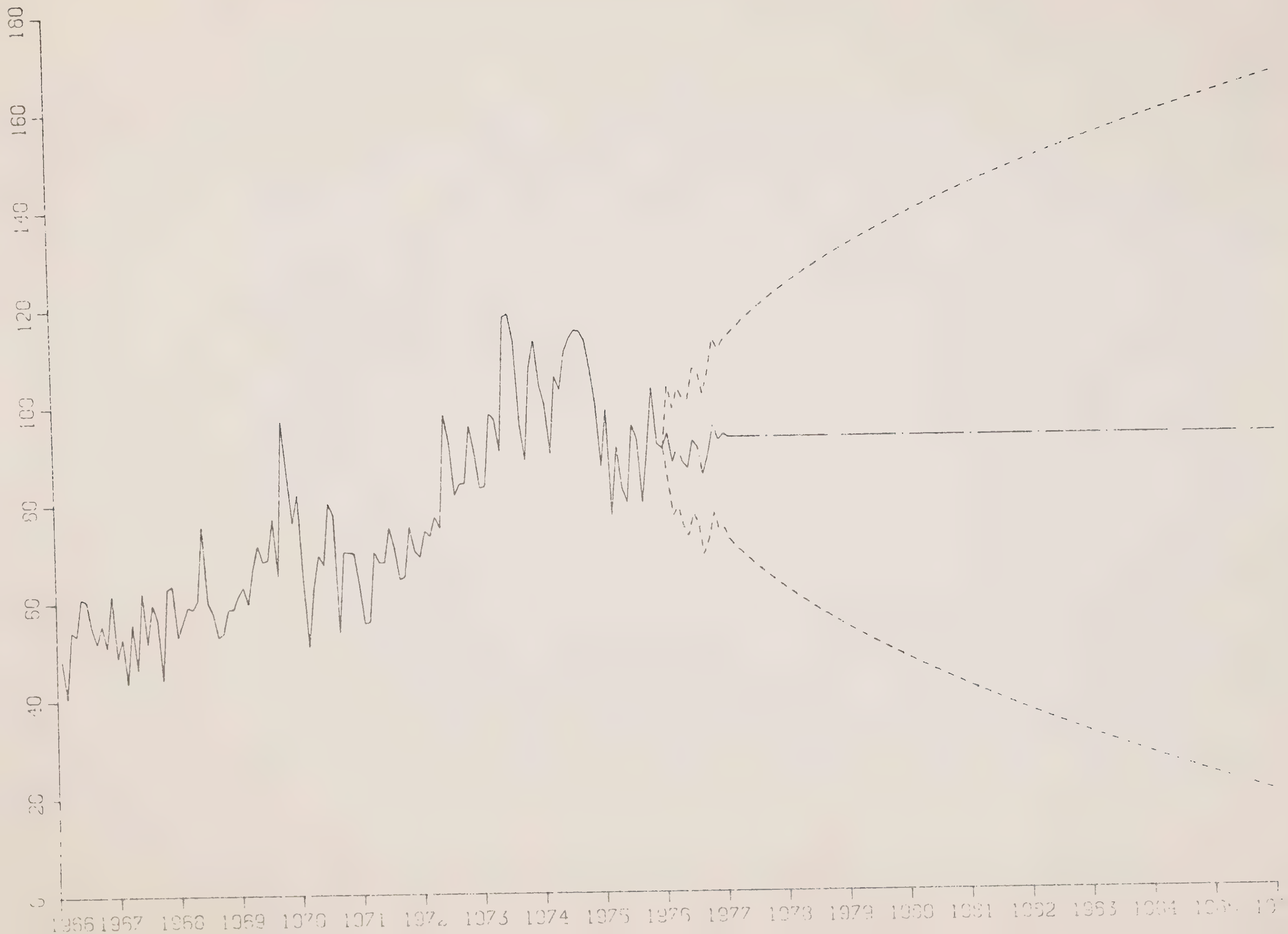
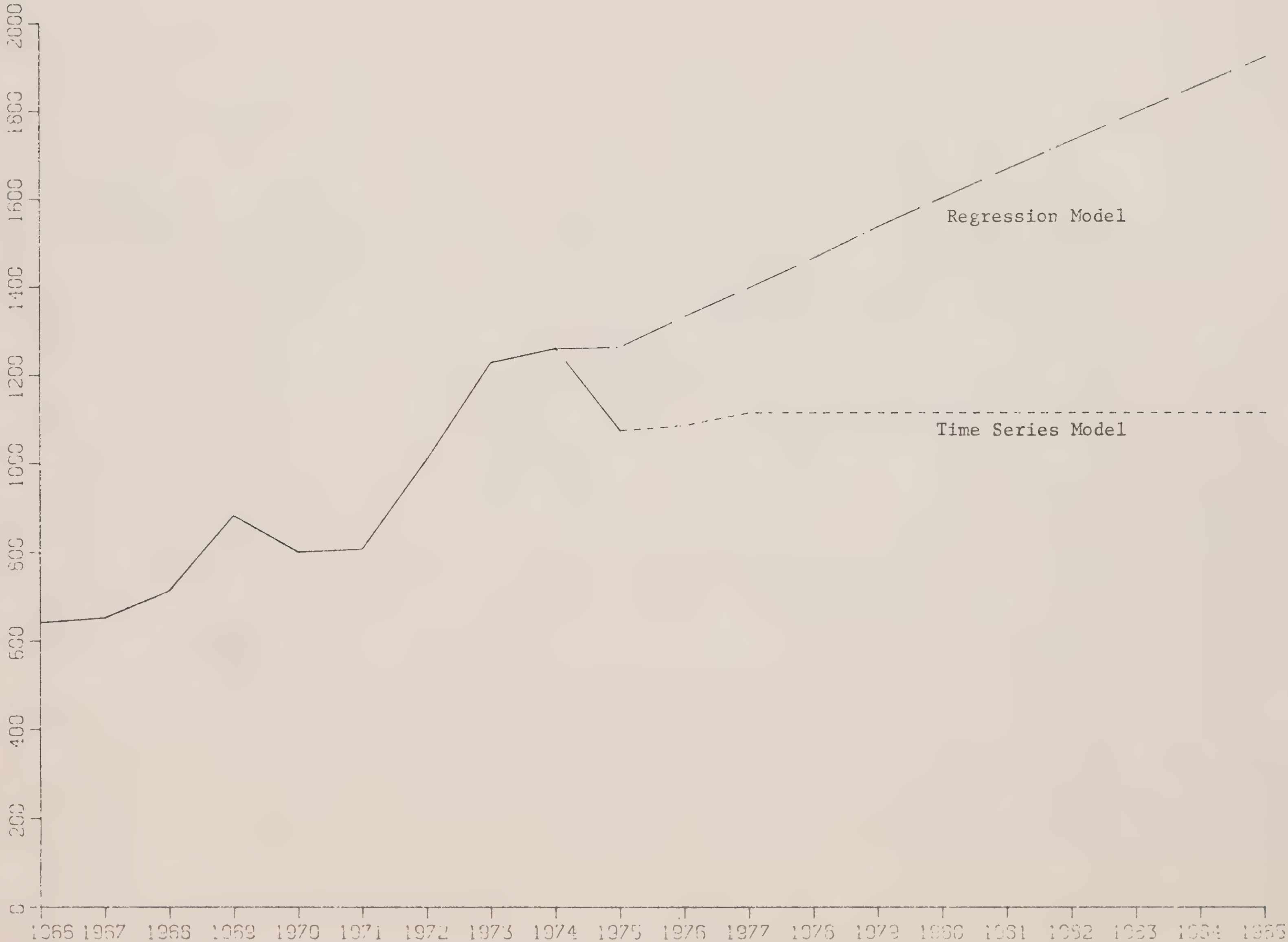


Figure 6.17: A comparison between the Regression Model and the Time Series Model for the Annual imports of Chemicals from the United States to Ontario in thousands of tons



6.12 Imports of Chemicals from the United States to the Prairie Provinces

Data on monthly imports of Chemicals from the United States to the Prairie Provinces from January 1966 to December 1975 appear in Figure 6.18 where the effect of high demand in 1973 and 1974 is evident. The mode of transportation includes rail and truck in significant proportion. If Z_t represents the movement during month t in millions of tons then Z_t may be described by an autoregressive time series model

$$\underset{(\pm 0.166)}{(1 - 0.491\,B} - \underset{(\pm 0.165)}{0.405\,B^2)}\tilde{Z}_t = a_t$$

$$\tilde{Z}_t = Z_t - \underset{(\pm 0.004)}{0.0126}$$

where the residual standard error is estimated to be 0.0025. Diagnostic checks applied to the residuals indicate that the model is adequate.

The model suggests that the series is stationary about a constant level with no seasonal component: monthly forecasts to December 1985 using this model also appear in Figure 6.18 together with their 75% confidence limits. The data and forecasts on an annual basis are given in Table 6.11 and are compared with data and forecasts from the earlier regression model in Figure 6.19. The time series results project a stable annual import level of 140,000 tons while the regression model presents an increasing trend. Since there are plans to considerably increase petrochemical output in the Prairies after 1979, it is expected that imports of organic Chemicals will not increase although there might be a minor growth in the import of some types of inorganic Chemicals. Overall, this link is not expected to exhibit a significant growth in movements.

Table 6.11: Annual imports of Chemicals from the United States to the Prairie Provinces in thousands of tons: the forecasts were derived from the time series model

Year	Data	Year	Forecasts
1966	75	1978	150
67	112	79	150
68	125	80	140
69	119	81	140
70	105	82	140
71	116	83	140
72	183	84	140
73	204	85	140
74	245		
75	160		

Figure 6.18: Monthly imports of Chemicals from the United States to the Prairie Provinces in thousands of tons

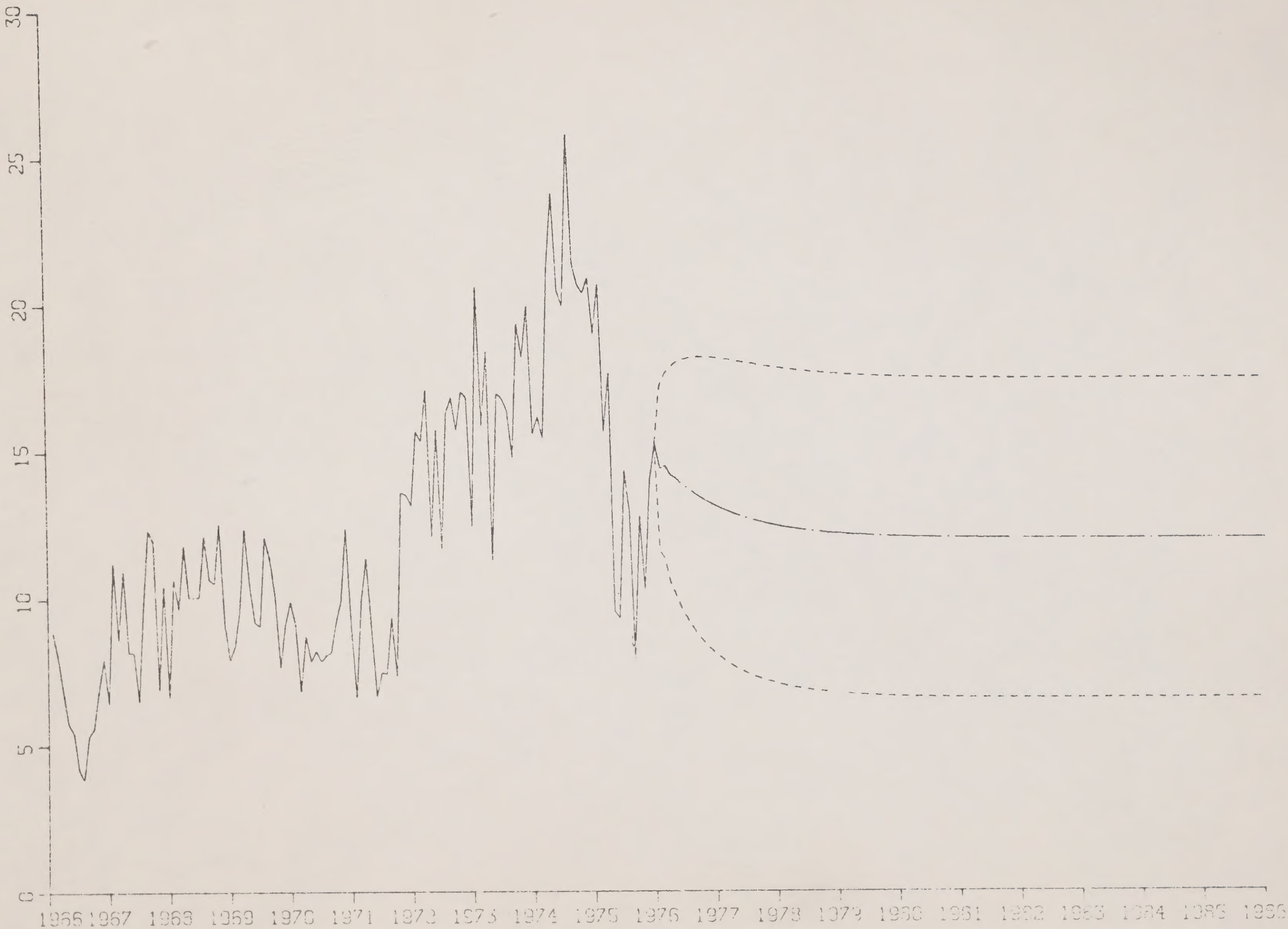


Figure 6.19: A comparison between the Regression Model and the Time Series Model for the Annual imports of Chemicals from the United States to the Prairie Provinces in thousands of tons